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PRACTICAL HELPS IN THE STUDY AND TREATMENT OF HEAD INJURIES

ADOLPH M. HANSON, M.D.

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Practical Helps in the Study and Treatment of Head Injuries

ADOLPH M. HANSON, M. D.

Formerly Neurosurgeon to Evacuation Hospital No. 8, American Expeditionary Forces.

WITH 91 ILLUSTRATIONS

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Dedicated to the memory of my teacher

JOHN BENJAMIN MURPHY

FOREWORD

The writer has long felt that the presentation of Head Injuries, in an elementary and brief form, would be welcomed by the profession at large. The demands of a general Practice do not permit of exhaustive study in special fields and the increased number of injuries to the head, due to the automobile and the greater industrial activities, renders it imperative that the general practitioner should be familiar with the essential facts relative to such injuries, in an elementary way, at least, in order to cope intelligently with this problem. Many lives, that are now lost, may be saved by prompt and proper care.

It is not the intention of the writer to convey the impression that the knowledge, that this little book offers, is sufficient to produce Neurosurgeons, nor does he offer this elementary treatment of a big subject as anything but a stimulus, to those called upon to care for head injuries, to seek a more thorough knowledge by referring to the great authorities in this field. It is a great step forward from a simple sub-temporal decompression to attempting the approach to an obscure brain tumor, or the severing of the posterior root of the Gasserian ganglion.

The writer has attempted by simple illustrations and photographs, rather than by much writing, to

render as clear as possible the elementary facts that are so essential to a clear understanding of the subject. Much of it is a brief and elementary review of what most Medical students in the Freshman and Sophomore years know. Chapter II is a brief description, with much, not essential to a diagnosis in a simple way, purposely omitted. The reader may refer to any recognized text-book on Anatomy for details not dealt with in this book.

The writer most gratefully acknowledges his obligations to Dr. Harvey Cushing for his permission to include some of his illustrations as published in an article entitled: "Penetrating Wounds of the Brain," the British Medical Journal for February 23, 1918. These illustrations consist of A. K. Maxwell's drawings and photographs and are included as Figures, 44, 45, 47, and 50 in Chapter V and as Figures 65, 66, 67, 68, 69, 70, 71, 72, 73, 74 and 75 in Chapter VII.

The writer has made liberal use of his notes on the lectures, delivered by Dr. Thomas H. Weisenburg, University of Pennsylvania Medical School, at the first School of Neurosurgery in 1917.

This short treatise is offered as a hand-book for ready reference.

Sincerely,

ADOLPH M. HANSON.

Faribault, Minnesota, U. S. A.
February 26, 1925.

CONTENTS

Chapter		Page
1	The Skull	13
2	The Brain	24
3	The Cranial Nerves	39
4	Injuries to the Scalp	53
5	Fractures of the Skull	64
6	Injuries to the Brain	75
7	Gunshot Injuries to the Head	91
8	The Costo-Chondral Graft	100
	Appendix	106

ILLUSTRATIONS

Figure		Page
1	The true surface markings of the middle meningeal artery and its branches....Between	16-17
2	Illustration showing the relation of the middle meningeal artery and its branches to the zygoma and the external ear	15
3	Illustration showing the surface markings of the longitudinal sinus in relation to the frontal bone, the frontal sinus, the foramen caecum and the nose....	16
4	The course of the longitudinal sinus within the vault of the skull....Between	16-17
5	The surface markings of the lateral and transverse sinuses in relation to the mastoid and the external ear.....	17
6	The surface markings of the lateral, transverse, longitudinal and occipital sinuses and torcular herophili in relation to the mastoid, external ear and posterior aspect of the skull.....	17
7	(1) Frontal Sinus (2) Antrum of Highmore....Between	16-17
8	(1) Frontal Sinus (2) Ethmoid Sinuses.....Between	16-17
9	(1) & (3) Sphenoidal Sinus (2) Middle Ear...Between	16-17
10	(1) Cribriform plate of ethmoid (1st cranial nerve) (2) Optic Foramen (2nd cranial nerve) (3) Anterior lacerated foramen (3rd, 4th, Ophthalmic Division of 5th and 6th cranial nerves) (4) Foramen Rotundum (Maxillary Division of 5th cranial N.) (5) Foramen Ovale (Mandibular Division of 5th cranial N.) (6) Foramen Spinosum (Middle Meningeal Artery) (7) Internal Auditory Meatus (7th and 8th Cranial Nerves) (8) Anterior Condyloid Foramen (12th Cranial Nerve) (9) Posterior Lacerated or Jugular Foramen (9th, 10th and 11th Cranial Nerves and Blood sinus to form beginning of deep jugular vein) .....Between	16-17
11	(1) Crista Galli of Ethmoid. (2) Optic Foramen. (3) Anterior Lacerated Foramen. (4) Foramen Rotundum. (5) Foramen Spinesum. (6) Foramen Ovale. (7) Internal Auditory Meatus. (8) Anterior Condyloid Foramen.....Between	16-17

Illustrations

Figure		Page
12	(1) Middle Lacerated Foramen into which the carotid canal opens postero-laterally, (2) Middle Meningeal Artery, (3) Foramen Magnum for exit of beginning of spinal cord and entrance of the vertebral arteries anteriorly. (4) Lateral Sinus, (5) Transverse Sinus, (6) Torcular Herophili.....Between	16-17
13	(1) Foramen Ovale, (2) Opening of Carotid Canal (3) Posterior Lacerated or Jugular Foramen (4) Stylo-mastoid Foramen (7th Cranial Nerve) (5) Posterior Condyloid Foramen (Emissary vein from blood sinus).....Opposite	24
14	(1) Foramen Oval (exit for the mandibular division of the 5th Cranial Nerve. (2) Foramen Spinosum (entrance for Middle Meningeal Artery). (3) Posterior Lacerated Foramen (exit for 9th, 10th and 11th Cranial Nerves). (4) Anterior Condyloid Foramen (exit for 12th Cranial Nerve.).....Opposite	25
15	The Certical Centers on the Lateral Aspect of the Cerebrum	30
16	The Certical Centers of Vision on the Posterior mesial surface of the cerebrum.....	32
17	The fields of Vision.....	41
18	Left Homonymous Hemionopsia.....	42
19	Schematic Illustration of the Quadrants of the Visual Field	43
20	Schematic Illustration of Right Upper Quadrant Anopsia	43
21	Right Lower Quadrant Anopsia.....	44
22	Central Blindness. Lesion on left occipital lobe.....	44
23	Tripod Incision.....	55
24	Tripod Incision.....	55
25	Closure of Tripod Incision.....	56
26	Linear Incision.....	56
27	Angled Tripod Incision.....	57
28	Closure of Angled Tripod Incision.....	58
29-38	Zig-zag Incisions.....	61-62
39	The Four-tail Bandage.....	68
40	Fracture of the base of the skull with complete transverse fracture of the face, illustrating the use of the four-tail bandage.....Between	72-73
41	Illustrating the use of the four-tail bandage and long wires, which hold right maxillary bone firmly attached to the intact left maxillary bone, protruding from mouth. .....Between	72-73

Illustrations

Figure		Page
42	Illustrating the use of the silver plate to prevent excessive bulging ..... Between	72-73
43	Appearance of severe frontal fracture 28 days following injury ..... Between	72-73
44	Illustrating the use of the perforator or knife-point drill.	71
45	Illustrating the use of the bur.....	71
47	Illustrating the use of the Montevnosi linear bone cutting forceps	72
46	Dural Separator and Bone Elevator for Craniotomy Between	72-73
48	Photograph of bone removed en bloc (external aspect) Between	72-73
49	Photograph of bone removed en bloc (internal aspect) Between	72-73
50	Illustrating the Application of silver clips to dural vessels	73
51	Illustrating the winding of silver wire about specially designed post preparatory to cutting along lateral grooves to make clips..... Between	72-73
52	Illustrating the removal of clip by clip-holder Between	72-73
53	Photograph of clip-holder with clip ready for application to vessel..... Between	72-73
54	Cushing's Esquillectomy Forceps..... Between	72-73
55	The Fleischer Spinal Manometer (improved) .. Between	72-73
56	Illustrating the curved incision for sub-temporal decompression	83
57	Illustrating the linear incision for sub-temporal decompression	84
58	Sub-temporal decompression on the third day when the stitches were removed..... Between	72-73
59	The Osteo-plastic Flap Decompression, showing the bone and dural flap reflected..... Between	88-89
60	The Osteo-plastic Flap decompression, showing the dura replaced, but not sutured. Note the defect in lower anterior portion of bone flap as the result of earlier sub-temporal decompression..... Between	88-89
61	The Osteo-plastic Flap Decompression-galeo sutured. Between	88-89
62	The Towel Bandage..... Between	88-89
63	The Towel Bandage..... Between	88-89
64	The Towel Bandage..... Between	88-89
65	Penetrating Wound of left temporal region..... Between	88-89
66	Tripod Incision after suture..... Between	88-89
67	Tripod Incision after suture..... Between	88-89

Figure		Page
68	Tripod Incision-sutures removed.....Between	88-89
69	Tripod Incision-sutures removed.....Between	88-89
70	Illustrating the use of Isle of Mann Incisions.....	93
71	Illustrating closure when Isle of Mann incisions are used	83
72	Illustrating the appearance of the external and internal surfaces of a piece of skull removed en bloc.....	83
73	Illustrating the use of the catheter in locating foreign bodies in the brain	94
74	Illustrating the use of the catheter, syringe and bulb in applying gentle suction in cleansing the track in the brain	94
75	The Telephone Probe.....Between	88-89
76	Showing drainage favored by gravity.....Between	88-89
77	Illustrating the "pinching" of cerebral cortex and how the convexity is less marked in large defects	102
78	Illustrating the sites of choice in selecting material for the costo-chondral graft	103
79	Illustrating the restoration of the internal table when the costo-chondral graft is applied as described by the author	105
80	Photograph of patient before operation for skull repair Between	96-97
81	Showing defect in skull exposed.....Between	96-97
82	Showing costo-chrondral ribs selected for graft exposed Between	96-97
83	Showing the cutting of the graft.....Between	96-97
84	Graft ready for application to skull defect.....Between	96-97
85	Graft in place with cut surfaces external. The two forceps indicate the length of the costo-chondral rib in the lower part of the defect.....Between	96-97
86	Showing the appearance of the forehead after suture of the frontalis muscle.....Between	96-97
87	Showing the appearance of the forehead after suture of the skin.....Between	96-97
88	Showing how the fields of operation are prepared, which permits the operator to transfer the graft from the chest directly to the skull defect without unnecessary handling .....Opposite	104
89	Showing the result six weeks after the operation for skull repair .....Opposite	104
90	Chart of Skull and its Sutures	107
91	Chart of Brain	105

Practical Helps in the Study and Treatment of Head Injuries

Chapter I

THE SKULL

The Skull at birth differs from the adult skull in that the cranial portion of the skull predominates greatly over that of the facial portion. The separation of the cranial bones at the sutures leaves six membranous spaces: the anterior fontanelle, bounded by the right and left halves of the frontal bone and the two parietal bones; the posterior fontanelle, bounded by the parietal bones and the occipital bone; the two lateral fontanelles, on either side, the anterior bounded by the greater wing of the sphenoid, the squamous portion of the temporal, the parietal and frontal bones, and the posterior fontanelle bounded by the squamous portion of the temporal, the occipital and parietal bones. The bones of the vault of the infant skull consist of one layer without any diploe. The inside of the skull shows the absence of grooving for vessels, blood sinuses and cerebral convolutions. The mastoid processes are absent and the air sinuses do not develop until puberty.

The bones of the skull are eight in number: the frontal, the two parietal, the occipital, the two tem-

poral, the sphenoid and ethmoid. The coronal suture is the suture formed by the apposition of the two parietal bones with the frontal. The lambdoidal suture is that formed by the apposition of the two parietals with the occipital. The suture at the junction of the two parietals at the vertex is known as the sagittal suture. The junction of the sagittal and coronal sutures is called the bregma, and that of the sagittal and lambdoid sutures, the lambda.

The prominence above the base of the nose, formed by the union of the superciliary ridges, is known as the glabella, while the external occipital protuberance is known as the inion.

The bones of the cranium consist of two hard shells of bone, an internal and an external table, with intervening cancellous bone, in which are numerous small venous sinuses forming a veritable net work and known as the diploe of the skull. Some of these diploe are so large that it is necessary to occlude them during the couse of an operation by the use of bone-wax, especially, in those cases in which the loss of blood has already been great.

The bones of the face are fourteen in number: 2 nasal, 2 maxillary, 2 lacrimal, 2 malar, 2 palatine, 2 inferior nasal conchae, the vomer and the mandible. The facial bones of interest in injuries to the face are: the 2 nasal, 2 maxillary, 2 malar, the vomer and the mandible. The common fracture, in frontal injuries, is that which leaves a line of separation through the zygomatic processes, both orbits and the base of the nose, separating the

facial bones from the base of the skull, but, at the same time, very often, leaving the normal articulation of the mandible with the temporal bones.

The two points of particular interest in fractures of the vault, the frontal, occipital and temporal regions of the skull are the relations of the middle meningeal artery and the blood sinuses to the inner surface of the cranial bones. Figure 1 shows the true surface markings of the middle meningeal artery and its branches, while Figure 2

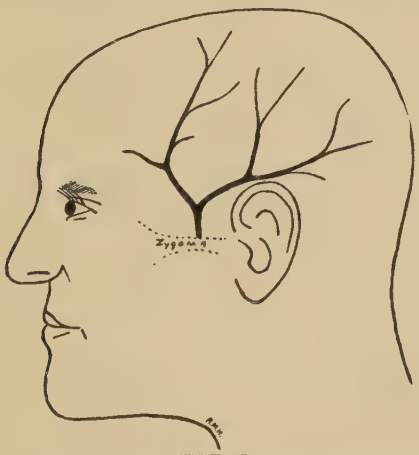


FIG. 2

Illustration showing the relation of the middle meningeal artery and its branches to the zygoma and the external ear.

is a schematic illustration, showing the relation of the middle meningeal artery to the zygoma and the external ear. Figure 3 illustrates the surface markings of the longitudinal sinus in relation to the frontal bone, the frontal sinus, the foramen caecum and the nose. Insert Figure 4 is a photograph show-

ing the course of the longitudinal sinus within the vault of the skull. Figure 5 illustrates the surface markings of the lateral and transverse sinuses in relation to the mastoid and the external ear, while Figure 6 shows the surface markings of the lateral, transverse, longitudinal and occipital sinuses and torcular herophili in relation to the mastoid, external ear and posterior aspect of the skull.

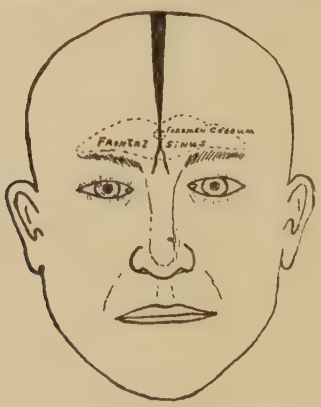


FIG. 3.

Illustration showing the surface markings of the longitudinal sinus in relation to the frontal bone, the frontal sinus, the foramen caecum and the nose.

The air sinuses will be briefly described as they are of interest in cases of fracture, when they may become infected, and in those cases of gunshot wounds in which the foreign body may be located in one of them. The air sinuses of the skull are hollow air spaces lined with mucous membrane that contain air and communicate with the nasal cavities.

The frontal sinus is a large cavity in the frontal bone, which gives rise to the superciliary prom-

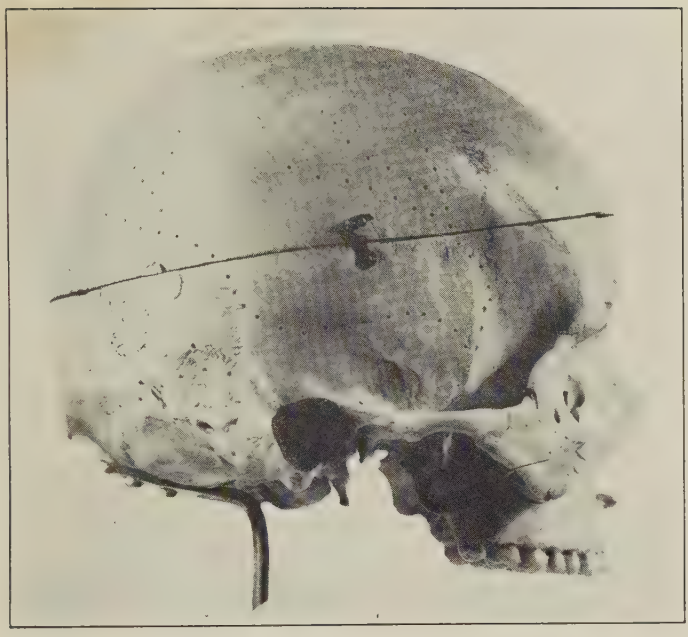


FIG. 1

The true surface markings of the middle meningeal artery and its branches.

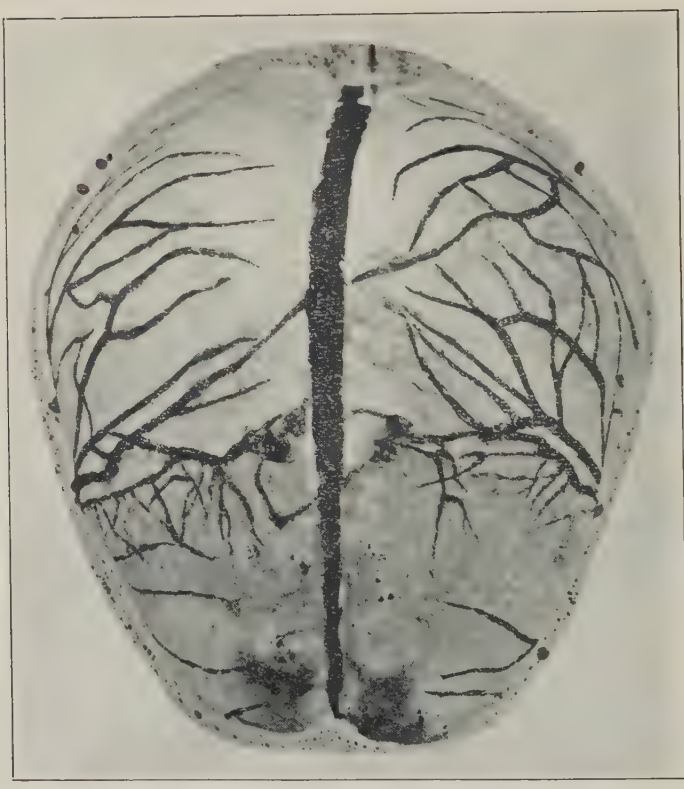


FIG. 4.

The course of the longitudinal sinus within the vault of the skull. Note how it becomes smaller anteriorly.

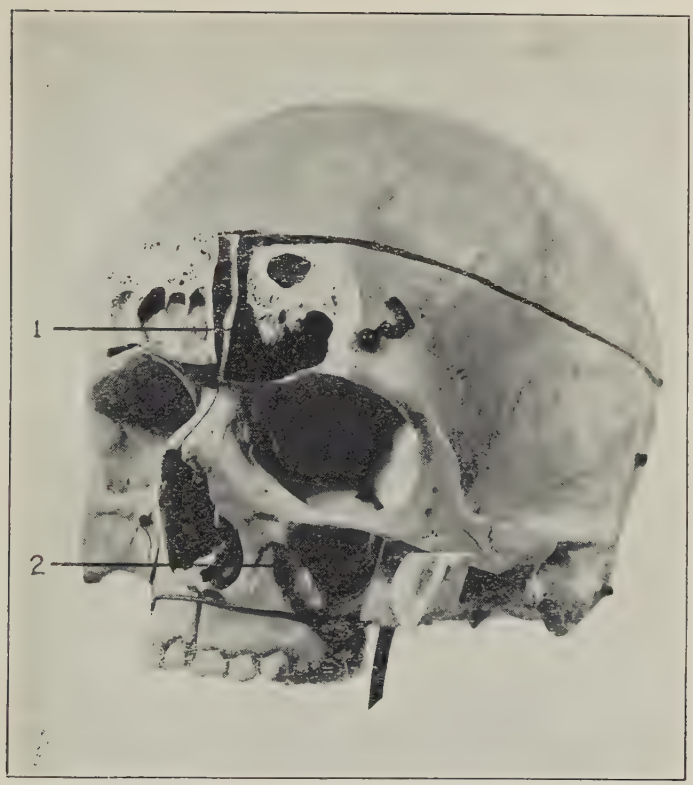


FIG. 7.

(1) Frontal Sinus. (2) Antrum of Highmore.

FIG. 8.

(1) Frontal Sinus. (2) Ethmoid Sinuses.

FIG. 9.

(1 and 3) Sphenoidal Sinus. (2) Middle Ear.

FIG. 10.

(1) Cribriform plate of ethmoid (1st cranial nerve.)
(2) Optic Foramen (2nd cranial nerve).
(3) Anterior lacerated foramen (3rd, 4th, Ophthalmic Division of 5th and 6th cranial nerves).
(4) Foramen Rotundum (Maxillary Division of 5th cranial).
(5) Foramen Ovale (Mandibular Division of 5th cranial N.)
(6) Foramen Spinosum (Middle Meningeal Artery).
(7) Internal Auditory Meatus (7th and 8th Cranial Nerves).
(8) Anterior Condyloid Foramen (12th Cranial Nerve).
(9) Posterior Lacerated or Jugular Foramen (9th, 10th and 11th Cranial Nerves and blood sinus to form beginning of deep jugular vein).

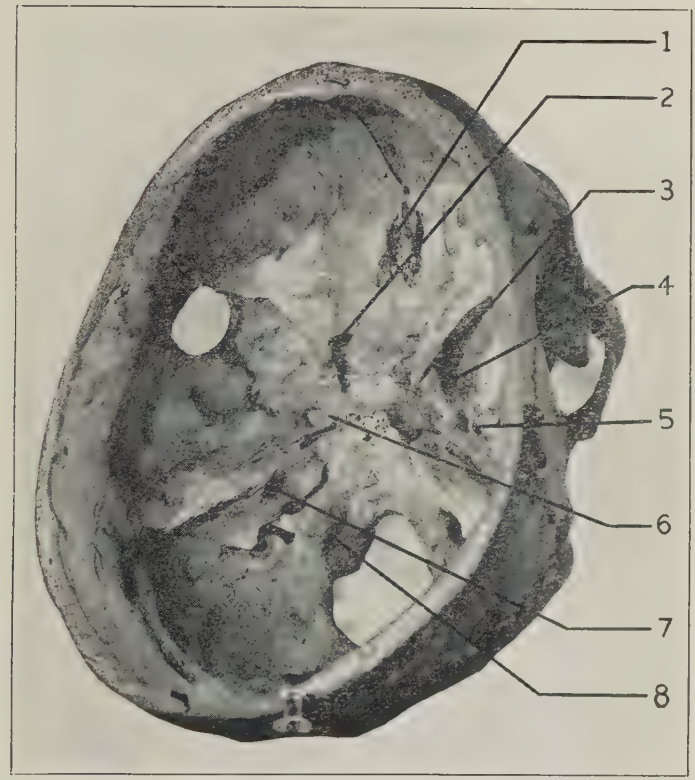


FIG. 11.

(1) Crista galli of ethmoid. (2) Optic Foramen. (3) Anterior Lacerated Foramen. (4) Foramen Rotundum. (5) Foramen Spinesum. (6) Foramen Ovale. (7) Internal Auditory Meatus. (8) Anterior Condyloid Foramen.

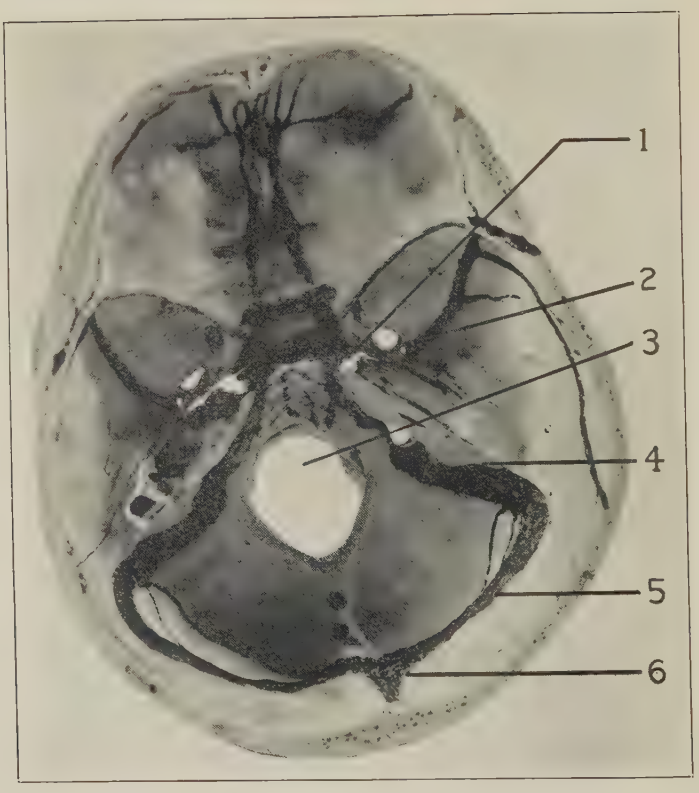


FIG. 12.

(1) Middle Lacerated Foramen into which the carotid canal opens postero-laterally. (2) Middle Meningeal Artery. (3) Foramen Magnum for exit of beginning of spinal cord and entrance of the vertebral arteries anteriorly. (4) Lateral Sinus. (5) Transverse Sinus. (6) Torcular Herophili.

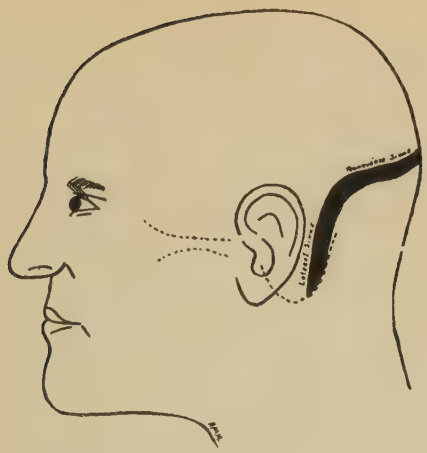


FIG. 5.

The surface markings of the lateral and transverse sinuses in relation to the mastoid and the external ear.

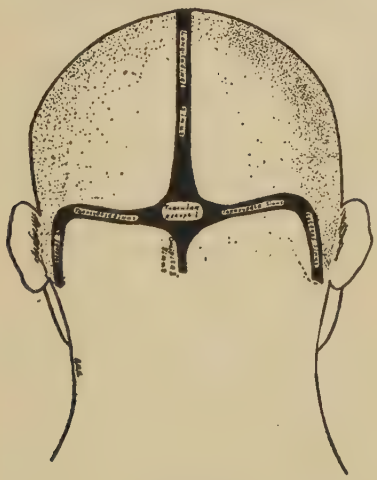


FIG. 6.

The surface markings of the lateral, transverse, longitudinal and occipital sinuses and torcular herophili in relation to the mastoid, external ear and posterior aspect of the skull.

inences. It is larger in men than in women and larger in some individuals than in others. It is separated from the orbits by a thin shell of bone and communicates with the nose. See Figure 7.

The antrum of Highmore, one in each maxillary bone, is a large air sinus that is also separated from the orbit by a thin layer of bone. The nasal wall of this sinus consists of a very thin bony wall, which may easily be perforated. See Insert Figure 7.

The ethmoid sinuses are numerous small air spaces on the nasal side of the orbit and separated from it by a very thin shell of bone. Insert Figure 8 is a photograph of a skull in which this thin layer of bone has been removed, revealing the ethmoid sinuses.

Insert Figure 9 is a photograph of the sectioned skull, revealing the sphenoidal sinus and its relation to the nose. The nasal wall of this sinus is very thin and easily perforated. It may be the site of infection following the common fracture in frontal injuries.

The Base of the Skull

The base of the skull is of particular interest, for it is in basal fractures that the general practitioner is most often called upon for treatment. Fractures at the base have always been considered as serious, as they should be. Familiarity with the base of the skull, considered as a whole, is essential to a clear understanding of the symptoms that may be met with in these fractures, and their signi-

ficance. The floor of the cranial cavity consists of three fossae: the anterior, middle and posterior. See Figures 10 and 11. Inserts.

The floor of the frontal fossa is formed by the orbital plates of the frontal bone, the cribriform plate of the ethmoid and the anterior portion of the body of the sphenoid and its lesser wings. In the median line, forward, is the crista galli of the ethmoid that serves as an attachment for the falx cerebri. Anterior to this is the foramen caecum, by which the longitudinal sinus communicates with veins of the nose, while anterior to the foramen is the frontal crest for the attachment of the falx. On either side of the crista galli, lies the olfactory groove, formed by the cribriform plate, for the support of the olfactory bulb, whose numerous olfactory nerves enter it by way of the perforations in the plate. The frontal fossa is of interest in so far as it serves as the roof for both bony orbits, supports the frontal lobes of the brain and serves as an entrance for the olfactory nerves (1st cranial nerve), and communicates with the nose in event of fracture.

The middle fossa is deeper than the frontal. It is narrow mesially and wide laterally. It is bounded anteriorly by the anterior margin of the chiasmatic groove, the anterior clinoid processes and the posterior margins of the lesser wings of the sphenoid; laterally, by the greater wings of the sphenoid, the sphenoidal angles of the parietal bones and the squamous portions of the temporal bones; poster-

iorly, by the superior angles of the petrous portions of the temporal bones and the dorsum sellae. The middle part, or center, of the fossa is bounded anteriorly by the tuberculum sellae and the chiasmatic groove, which ends at either side of the optic foramen which serves as the exit for the optic nerve and ophthalmic artery. Above and behind, the anterior clinoid processes are directed backward and afford attachment for the tentorium cerebelli. Behind the tuberculum sellae is a depression called the sella turcica, which lodges the pituitary body. The sella turcica is bounded anteriorly by the anterior wall of the fossa, which extends on either side unto the middle clinoid process; posteriorly, by the dorsum sellae, whose finger-like processes are called the posterior clinoid processes. Below each posterior clinoid process is a notch for the sixth cranial nerve. The posterior clinoid processes also serve as attachments for the tentorium cerebelli. The carotid groove lies on either side of the sella turcica. It begins posteriorly at the middle lacerated foramen, where the internal carotid artery enters the skull and takes a slightly curved course to ascend between the anterior and middle clinoid processes to join the circle of Willis at the base of the brain. In this groove, the internal carotid artery is surrounded by a plexus of sympathetic nerves. The carotid groove also contains the cavernous sinus, a plexus of veins, whose thrombosis produces a pulsating exophthalmus. The lateral portions of the middle fossa are

deep and contain the temporal lobes of the cerebrum.

The middle fossa contains the following foraminae: the optic, the anterior lacerated, the foramen rotundum, the foramen ovale, the foramen spinosum and the middle lacerated foramen. The optic foramen serves as the exit for the ophthalmic artery and the second cranial nerve; the anterior lacerated foramen, for the exit of the third, fourth, ophthalmic division of the fifth and the sixth cranial nerves; the foramen spinosum, for the entrance of the middle meningeal artery; the foramen rotundum, for the exit of the maxillary division of the fifth cranial nerve; the foramen ovale, for the exit of the mandibular division of the fifth cranial nerve and the middle lacerated foramen for the entrance of the internal carotid artery. The Gasserian ganglion lies internal to the foramen rotundum, the foramen ovale and the foramen spinosum, and external to the internal carotid artery and the posterior portion of the cavernous sinus. See Figures 10, 11 and 12, Inserts.

The posterior fossa is the largest and deepest of the three fossae. It is formed by the dorsum sellae and the posterior clinoid processes of the sphenoid, the petrous and mastoid portions of the temporal bones, the mastoid angles of the parietal bones and the occipital bone. The superior angles of the petrous portions of the temporal bones serve as attachment for the tentorium cerebelli. This fossa contains the cerebellum, the pons varolii and the

medulla oblongata. The following foraminae are found: the internal auditory meatus in the petrous portion of the temporal bone for the exit of the seventh and eighth cranial nerves; the posterior lacerated, or jugular foramen, situated between the petrous portion of the temporal bone and the occipital bone, for the exit of the blood sinus and the ninth, tenth and eleventh cranial nerves, and for the entrance of a few meningeal arteries from the occipital and ascending pharyngeal arteries; the anterior condyloid foraminae, for the exit of the twelfth cranial nerves; the posterior condyloid foraminae, for the exit of an emissary vein from the blood sinus; the foramen magnum, for the exit of the beginning of the spinal cord and for the entrance of the vertebral arteries. On the groove formed by the basilar process of the occipital bone and the posterior part of the body of the sphenoid, anterior to the foramen magnum, rests the medulla oblongata and pons. The posterior fossa is grooved for the transverse, lateral, occipital and superior petrosal sinuses. See Figures 10, 11 and 12.

The external aspect of the base of the skull is of interest in that, here, we find the opening of the carotid canal by which the internal carotid artery enters the skull. It traverses the carotid canal in the petrous portion of the temporal bone in a forward direction to emerge mesially into the middle lacerated foramen. Note the close relation of this opening to the posterior lacerated, or jugular fora-

men. Here, also, external to these foraminae, at the base of the stylo-mastoid process, posteriorly, is found the stylo-mastoid foramen for the exit of the seventh cranial nerve. See Insert Figure 13.

If the external aspect of the base of the skull is viewed from in front, the following foraminae will be seen: the foramen ovale, for the exit of the mandibular division of the fifth cranial nerve; the foramen spinosum, for the entrance of the middle meningeal artery; the posterior lacerated, or jugular foramen, for the exit of the ninth, tenth and eleventh cranial nerves and the deep jugular vein; the anterior condyloid foramen, for the exit of the twelfth cranial nerve; and, the foramen for the exit of the beginning of the spinal cord and the entrance of the vertebral arteries in its anterior portion to form the basilar artery. See Insert Figure 14.

Chapter II

THE BRAIN

In briefly reviewing the brain, only the most elementary survey will be made, with especial reference to facts that are directly concerned in making a diagnosis following injuries to the head. The more complicated structures involved in diseases of the nervous system and such conditions that require the attention of expert Neurologists are purposely omitted.

To serve the elementary study intended by the writer, the brain may be described as consisting of four main parts: the cerebrum, the cerebellum, the pons varolii and the medulla oblongata. The surfaces of the cerebral hemispheres are thrown into numerous folds called convolutions, or gyri, and the crevices between them are called fissures, or sulci. Some of these convolutions are the seats of important centers and are, therefore, called "known" or "live" areas, while others are "unknown," or "silent" areas. These "silent" areas are areas that are imperfectly understood and do not seem to subserve any special function.

The weight of the brain at birth, compared with the total body weight, is 12 per cent., while, in the adult, the weight of the brain constitutes only 2 per cent. of the body weight. The average weight

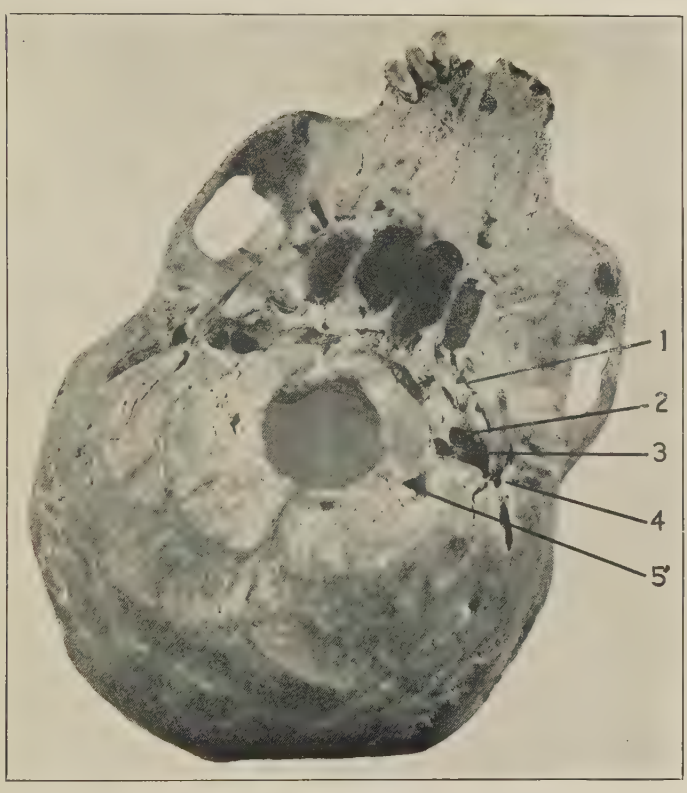


FIG. 13.

(1) Foramen Ovale. (2) Opening of Carotid Canal.
(3) Posterior Lacerated or Jugular Foramen.
(4) Stylo-mastoid Foramen (7th Cranial Nerve).
(5) Posterior Condyloid Foramen (Emissary vein from blood sinus).

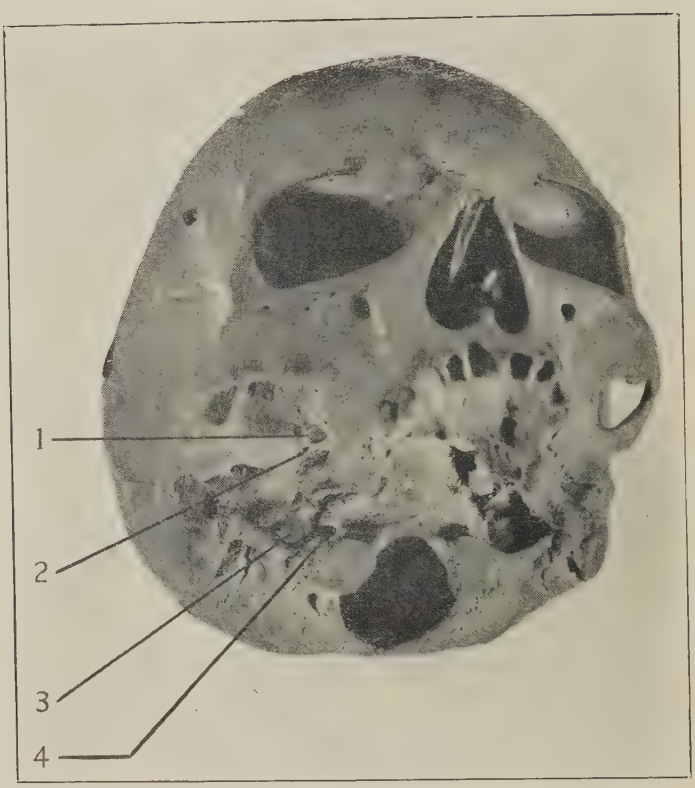


FIG. 14.

(1) Foramen Ovale (exit for the mandibular division of the 5th Cranial Nerve. (2) Foramen Spinosum (entrance for Middle Meningeal Artery). (3) Posterior Lacerated Foramen (exit for 9th, 10th and 11th Cranial Nerves. (4) Anterior Condyloid Foramen (exit for 12th Cranial Nerve.).

of the adult male brain is said to be 1360 grammes, or approximately 48 ounces, and that of the female, 1250 grammes, or about 44 ounces.

A dense membrane divides the cranium longitudinally and separates the two hemispheres. In its upper portion, it contains the longitudinal, or sagittal sinus. This membrane is called the falx cerebri. Another membrane, of a similar nature, divides the cranial chamber horizontally in its posterior portion, forming a roof for the posterior fossa and separates the occipital lobes of the cerebrum from the cerebellum. This membrane is known as the tentorium cerebelli, or roof of the cerebellum, and contains, in it attachments to the cranium, the transverse sinuses, torcular herophili and the superior petrosal sinuses just below the angle of the petrous portion of the temporal bones, posteriorly. The falx cerebelli is a membrane extending from the tentorium cerebelli to the foramen magnum, posteriorly, and contains, in its attachment to the skull, the occipital sinus.

The coverings of the brain are: the dura mater, the arachnoid and the pia mater. The dura mater is a dense fibrous membrane, composed of two layers, which covers the interior of the cranium. The outer layer is attached to the bone and is densely adherent to the sutures and the margins of the foraminae of the skull. It is continuous with the pericranium, the dura mater of the spinal cord and the periosteum of the orbit. The inner layer extends into the intervals, between parts of the brain, forming dense,

fibrous partitions: the falx cerebri, the tentorium cerebelli, the falx cerebelli and the diaphragma sellae (a horizontal circular fold which forms a roof for the sella turcica). The dura mater contains the meningeal arteries and veins and the large blood sinuses. The arachnoid is a delicate, transparent membrane, which covers the brain, but does not enter the fissures between the convolutions. It lies over the pia mater. The pia mater is a vascular membrane, which covers the brain and adheres densely to it. It covers the convolutions and dips down into the fissures. It helps to form the choroid plexus.

By the term "Meningitis" is meant an inflammation of one of the meninges, usually the dura mater. "Pachymeningitis" is the term applied to conditions in which all of the meninges are involved. Inflammation of the arachnoid and pia mater, in which the dura mater is not involved, is called "Leptomeningitis."

The Cerebral Hemispheres

The cerebral hemispheres constitute the major portion of the brain and subserve intellect and will, motion, sensations of touch, pain, heat and cold, sight, smell, hearing and speech. Memory is included under the general heading of intellect.

The main lobes of the cerebrum are: the frontal lobe, or fore-part of the cerebrum, which is bounded below by the fissure of Sylvius and posteriorly by the fissure of Rolando; the parietal lobe, which

extends from the fissure of Rolando to the parieto-occipital fissure; the occipital lobe, which is behind the parieto-occipital fissure; the temporal lobe, which rests in the middle fossa of the skull, bounded above by the fissure of Sylvius; the olfactory lobe, which is found like a club, large at the end, underneath the frontal lobe. Each hemisphere contains the lateral ventricle, which communicates with the third ventricle by the interventricular foramen, or the foramen of Munro.

Anterior to the fissure of Rolando, or Central fissure, in the Pre-central convolution, are the motor centers for the muscles of the opposite side of the body. The centers for the feet and lower limbs are found on the mesial side of the hemisphere and in the extreme upper portion, laterally, and extending downward, in the order mentioned, are the centers for the trunk, the upper extremities, the neck and, lastly, the head, so one may be said to be standing on ones head in the pre-central convolution in reference to the motor centers. Injuries to these centers produce a spastic paralysis of the part supplied on the opposite side of the body. It is rare to find a complete spastic hemiplegia due to injury, when the cortical centers are directly involved. In fact, a complete spastic hemiplegia, including the face, has never been met with in the writer's experience. A complete spastic hemiplegia is usually due to a rupture or thrombosis of the lenticulo-striate artery in the internal capsule.

Posterior to the pre-central convolution and the central fissure (fissure of Rolando) are found the centers for the primary sensations. By primary sensations, we mean the sensations of touch, pain, heat and cold. The location of these centers in the Post- central convolution, in reference to the parts of the body on the opposite side supplied by them, correspond to the position of the centers in the motor area.

By acquired sensations are meant the sensations of position, movement and pressure. The centers for these sensations are in the inferior and superior parietal convolutions: the centers for the upper limb are found in the inferior and lower portion of the superior lobe, while those for the lower limb are found in the upper portion of the superior lobe. These centers control the acquired sensations of the opposite side of the body. Again, we find this inverted arrangement in reference to the opposite side of the body. See Figure 15. If these centers are injured, or destroyed, there will be ataxia in the opposite side of the body. This can be distinguished from locomotor ataxia in that the latter involves both sides of the body. Lesions of the parietal convolutions interfere with the sensations of localization, position and movement. They produce Astereognosis, which is the inability to recognize objects by touch or feel. This may be tested by asking the patient, with eyes closed, to call the names of objects placed in the outstretched hand. In patients, with a total loss of this sense, no differentiation

can be made between a silver dollar and a pocket-knife, a watch, or a key. In testing for sense of position, the patient may be asked to place a limb forward, backward, or to either side, or to move it in a certain direction. In testing for sense of localization, the patient may be asked to touch the tip of the nose with the index finger, or to place the heel of one foot on the knee of the opposite limb, etc.

The cortical centers for speech are those for Ability to Speak (Motor Speech Center), Ability to Write (also Motor), Understanding of Speech, or Word Hearing and Understanding of Writing, or Word Seeing. Speech is a homolateral function, the centers being in the left cerebral hemisphere in right handed individuals and vice versa. The Motor Speech Centers (Ability to Speak) are located in Broca's convolution, which lies near the end of the anterior limb of the Sylvian fissure and anterior to the Head center in the pre-central convolution. The motor center for written letters and words lies above Broca's area and is in close proximity to the center for Head and Eye movements, which is situated anterior and a little below it. Injuries to these centers produce Motor Aphasia (inability to talk) and Motor Agraphia (inability to write). This loss may be complete, or incomplete, depending upon the severity of the lesion. See Figure 15.

FIG. 15.
The Certical Centers on the Lateral Aspect of the Cerebrum.

The Sensory Speech center (Understanding of Speech) is found in the mid-temporal convolution. A lesion at this point produces Sensory Aphasia. Such a patient cannot understand what is said. See Figure 15.

The center for Word Seeing (Understanding of Writing) is located in the Angular convolution (or gyrus), which is continuous with the superior temporal convolution. Injury to this center produces Alexia, which is the inability to express oneself in written words, even though able to copy letters and words, if the Motor Writing center (Ability to Write) is intact. See Figure 15.

The centers for Head and Eye Movements are bilateral and are found in the inferior frontal convolution, a little below and anterior to the center

for Ability to Write. An irritative lesion of these centers causes a deviation of the head and eyes, called conjugate deviation of the head and eyes, to the opposite side. If the lesion is destructive, the deviation of the head and eyes will be to the side of the lesion.

The centers for audition (hearing) are bilateral and are located in the superior temporal convolutions. See Figure 15.

The ideation centers and the centers for will, judgment and the aesthetic sense are located in the superior frontal convolution on the left side in right handed individuals and vice versa. The best of the known authorities differ as to the exact location of these centers, but the observations made by the writer, during the World War, lead him to believe that the statement in the preceding sentence is true. It must be admitted that head injuries, in which other parts of the cerebrum were directly involved, gave evidence of being indecent, slothful in habits, indifferent and profane, but, in these cases, an edema of the frontal lobes was undoubtedly present. Injuries of the frontal lobes, in the left, if right handed and vice versa, almost invariably exhibited the symptoms mentioned. See Figure 15.

Figure 16 illustrates the location of the cortical centers of vision, located on the mesial side of each hemisphere in the cuneus, calcarine fissure and lingual lobe. The cuneus controls vision of the lower quadrants of the visual field and the lingual lobe, the upper quadrants, while the center for central

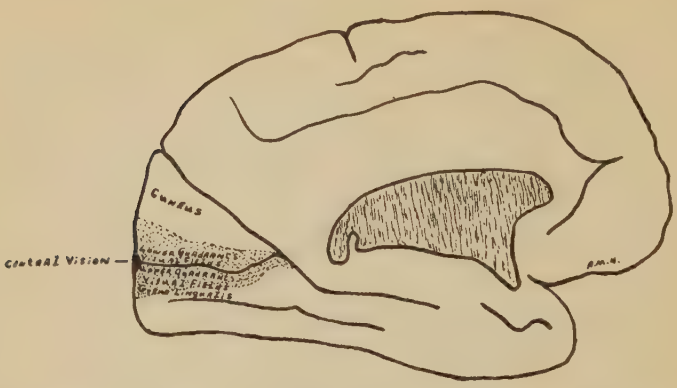


FIG. 16.
The Certical Centers of Vision on the posterior mesial surface of the cerebrum.

vision is at the extreme pole of the occipital lobe in the calcarine fissure. Injuries to the back of the head may cause partial or complete blindness, temporary or permanent, depending upon the severity of the lesion and the amount of loss of brain substance.

The cerebrum is composed of grey and white matter. The nerve cells make up what constitutes the outer layer of grey matter. This outer layer of grey matter is composed of alternating grey and white layers, nerve cells and nerve fibres, both medullated and non-medullated. The layers of cells from without inward are known as: the molecular layer, the outer layer of polymorphous cells, the layer of small pyramidal cells, the layer of large pyramidal cells and the inner layer of polymorphous cells. This outer layer of grey matter is relatively very thin (one-eight to one-fourth inch in thickness)

compared with the rest of the cerebrum and when this is born in mind, the irritation caused by small pieces of sharp depressed bone, or defects over "live" areas, should be given due consideration. If the lesion is irritative, operation holds out some hope of benefit by operative interference.

The white matter, which makes up the bulk of the cerebrum, excluding the nuclei, is composed of nerve fibres in a matrix of neuroglia cells. The fibres are arranged in three main different systems: the association fibres, which connect the various centers with one another; the commissural fibres, which unite the cerebral hemispheres with one-another (the corpus callosum); and, the projection fibres, which go to make up the cerebral peduncles, that connect the cerebrum with the rest of the brain and the spinal cord.

The peduncles of the brain contain the nuclei of the third and fourth cranial nerves.

The ventricles of the brain are four in number: the two lateral ventricles, found in the cerebral hemispheres, which communicate with the third ventricle by the foramina of Munro; the third ventricle, which is a narrow crease between the optic thalami and which communicates with the fourth ventricle by the aqueduct of Sylvius; the fourth ventricle, the floor of which is formed by the medulla oblongata and the roof, by the cerebellum. It communicates with the cisterna magna, or space below the tentorium, by the foramina of Luschka (foramina of Key and Retzius) and the foramen of Magendie.

The cisterna magna is the largest subarachnoid space. The foramen of Magendie is the central perforation in the tela choroidea inferior. The foramina of Luschka lie on either side of the foramen of Magendie. The extension of the fourth ventricle becomes the central canal of the spinal cord.

A plugging of the foramina of Munro, the aqueduct of Sylvius, or the foramina of Luschka and Magendie will produce hydrocephalus. There are two distinct types of hydrocephalus: external hydrocephalus, which is an accumulation of cerebro-spinal fluid in the subarachnoid spaces, and internal hydrocephalus in which the accumulation of fluid is confined to the ventricles.

The choroid plexus is a plexus of blood vessels, given off from the inferior cerebellar arteries, which is found in the fourth ventricle, the aqueduct of Sylvius, the third ventricle and through the foramina of Munro into the fourth ventricles, where it assumes its largest proportions. The choroid plexus is the source of the cerebro-spinal fluid.

The cerebro-spinal fluid, in normal amounts, is 80 to 120 c. c. It is a clear, transparent fluid, like the clearest water, with a specific gravity of 1.004. In disease (meningitis), this fluid becomes cloudy and may be so viscid that it will not run through a spinal puncture needle. Normal cerebro-spinal fluid may reveal an occasional cell under the microscope, while in meningitis the field may be full of cells. The normal intra-spinal pressure is said to be 12 to 20 millimeters of mercury, or 40 to 100

millimeters of water. Sharpe states the normal intra-spinal pressure, in practice, to be from 5 to 9 millimeters of mercury. As high as 12 millimeters of mercury may be considered normal, but when the pressure rises above 12, with pressure symptoms developing after a head injury, a decompression may become necessary.

The inter-brain, or mid-brain, is the region of the third ventricle. It consists of the optic thalami, the pineal body, the corpora geniculata, the tuber cinereum, the corpora albicantia and the optic chiasm. The optic thalami are two large oblong masses on either side of the third ventricle. They are connected by communicating fibres with the optic tract, the cerebral cortex, the corpora striata and the corpora albicantia. The corpora geniculata are four oval enlargements, found external and below the pulvinar of the thalamus, an anterior and a posterior one on either side. The external one receives the external fibres of the optic tract, while the internal one receives the medial fibres. These fibres of the internal geniculate body do not enter the eye, but communicate with the inferior corpora quadrigemina. These fibres go from the inferior quadrigeminal body by way of the optic commissure to the internal geniculate body of the opposite side. This is known as the commissure of Gudden. The corpora quadrigemina are four round bodies, found on the dorsal surface of the mid-brain as an anterior and a posterior pair, behind the third ventricle and below the posterior part of the corpus callosum.

The corpus callosum is the great transverse commissure uniting the two hemispheres and forming the roof of the lateral ventricles. It is composed of firm, white matter and is arched backward, with its convexity upward. It contains the commissural fibres that unite the different centers of the hemispheres with one another.

The hind-brain consists of the pons varolii, medulla oblongata and cerebellum and contains the floor of the fourth ventricle. The pons varolii contains the nuclei of the fifth, sixth, seventh and the upper portion of the eight cranial nerves. These nuclei are composed of grey matter and are found in the floor of the fourth ventricle. The major portion of the pons is composed of white matter.

The medulla oblongata, or spinal bulb, is the lowest portion of the brain and the most necessary to life, as it contains the centers that control the heart and respiration. It contains the lower portion of the floor of the fourth ventricle and the nuclei of the lower portion of the eighth, the ninth, tenth, eleventh and twelfth cranial nerves. Injuries to this portion of the brain are usually fatal. Fatal cases, resulting from head injuries, unless killed instantly, die because of the cerebral edema, which forces this portion of the brain into the foramen magnum, hence, the importance of knowing whether or not to do a decompression.

The cerebellum, like the cerebrum, consists of grey matter on the outside and white matter on the inside. It is composed of a central portion called

the vermis, because of its resemblance to a worm, and two lateral hemispheres. The cerebellum is connected with the rest of the brain by three peduncles: the superior, middle and inferior. The superior peduncles pass from the cerebellum upward under the corpora quadrigemina where the fibres cross, going to the red nucleus of the tegmentum and, through the optic thalamus, to the cerebral cortex. The superior medullary velum is a thin band of white matter, which connects the superior peduncles with one another and forms part of the roof of the fourth ventricle. The middle peduncles go to the pons and make up most of the fibres connecting one cerebellar hemisphere with the other by passing through the pons. The inferior peduncles connect the cerebellum with the medulla oblongata.

The cerebellum controls the coordination of muscles or groups of muscles in movements that are the result of habit or training, as in driving an automobile, running a machine, playing a pipe-organ, piano, sewing, knitting, swimming, running, etc . The vermis preserves trunkal synergy (proper coordination of the muscles of the trunk); the right hemisphere, those for the right side of the body: the upper portion for the upper limb and the lower portion for the lower limb, and vice versa. Lesions of the vermis will produce trunkal asynergy. Such a patient will have a tendency to fall forward or backward when walking or running. The patient

may run in an endeavor to avoid falling. Lesions of the hemispheres will produce asynergy in the limbs with a tendency to fall to the right or left of a straight line. Such patients would not be able to sew, play the piano, swim, etc.

Chapter III

THE CRANIAL NERVES

The first pair of cranial nerves, or the olfactory nerves, are, strictly speaking, not nerves, but a part of the brain. The olfactory bulbs, the two club-like extremities of the olfactory nerves lie on the cribriform plate of the ethmoid on either side of the crista gali. The smaller nerves coming from the Sneiderian membrane of the nose, pass through the holes in the cribriform plate and enter the bulbs. The fibres of these nerves are non-medullated. Deeply, the olfactory nerve connects with the brain by the medial root, which goes to Broca's area and the convolutions below the corpus callosum and the lateral root, which connects with the union of the uncinate and temporal convolutions and the middle grey root from the optic thalamus. The region of the uncinate convolution is recognized as the cortical center for smell.

Fractures at the base of the skull, involving the frontal fossa, may tear the olfactory bulbs away from the cribriform plate, severing the small nerves going into the bulbs. This causes a loss of the sense of smell called anosmia. The sense of taste is disturbed by this loss, as volatile substances, that may be smelled, are enhanced by this sense. The loss of sense of smell will greatly modify taste. Cor-

tical lesions, involving the base of the brain in the middle fossa, may give rise to a disturbance, or perversion, of the sense of smell called parosmia. Such patients may complain of bad odors, when none are present, or fail to recognize certain substances by their odor.

The second pair of cranial nerves, or Optic Nerves, are, also, strictly speaking, not nerves, but a part of the brain. The fibres originate in the retina of the eye and, leaving the eye-ball, form the optic nerve, which enters the skull at the optic foramen. The optic nerves extend from the eye-ball to the optic commissure, or chiasm. From the optic chiasm, the fibres form two bundles called the optic tracts, which go to the sub-centers: the external geniculate body, the pulvinar of the optic thalamus and the anterior quadrigeminal body. From these sub-centers, the fibres pass by way of the posterior portion of the posterior limb of the internal capsule to the cerebral cortex. The cortical centers of vision are found in the cuneus, the lingual lobe and the calcarine fissure.

In order to easily understand the significance of the centers of vision, it will be well to briefly consider the fields of vision. The fields of vision are divided into nasal and temporal fields, the temporal being the larger; into upper and lower quadrants and central and peripheral fields of vision. The true visual field is not round as illustrated in the drawing, representing nasal and temporal fields and the upper and lower quadrants. See Figure 17. The

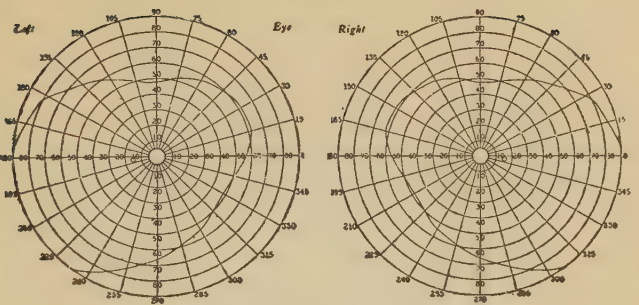


FIG. 17.
The Fields of Vision.

field of vision is larger than the color fields. Of the color fields, the blue, the red and the green are the most important. Their relative size is in the order mentioned, the blue being the largest.

Figure 18 illustrates the nasal and temporal fields of vision. The dotted lines represent the portions of both retinae, whose fibres go to the left occipital lobe and the unbroken lines, those going to the right occipital lobe. If the lesion is in the right occipital lobe, a left hemianopsia results, represented by the shaded portions in Figure 18. Homonymous hemianopsia is the condition in which the temporal field of vision of one eye and the nasal field of vision of the other eye are involved. In a left homonymous hemianopsia, there is blindness in the left temporal and the right nasal fields. The lesion, responsible for this condition, may be anywhere in the right optic tract, in the visual path in the posterior limb of the internal capsule on the right side, or in the visual cortex of the right cerebral hemisphere. See Figure 18, which represents

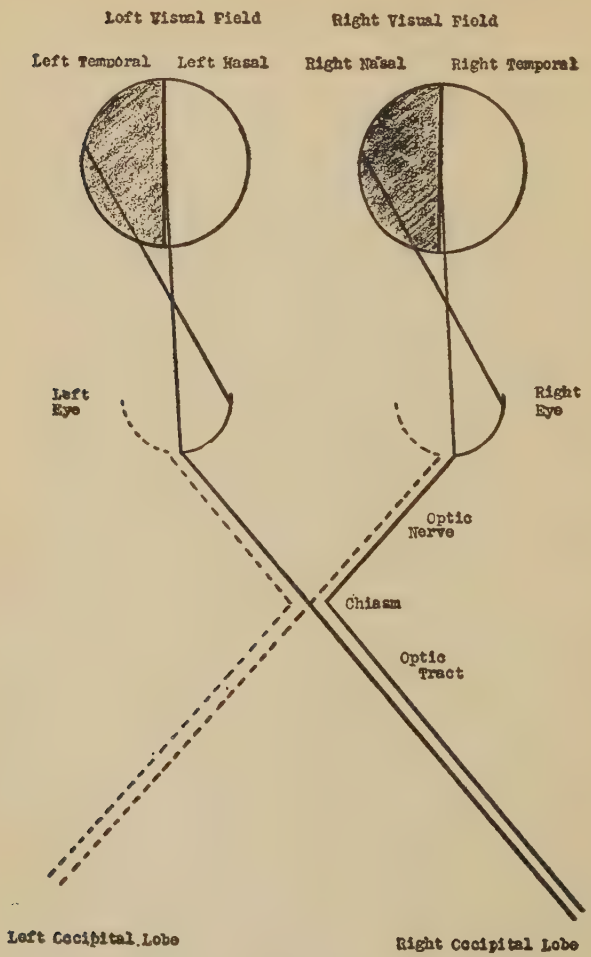


FIG. 18.
Left Homonymous Hemianopsia.

a left homonymous hemianopsia. If the lesion is in the internal capsule, hemiplegia on the opposite side may occur. If the geniculate body is involved,

there may be an interference with the proper co-ordination of the ocular muscles.

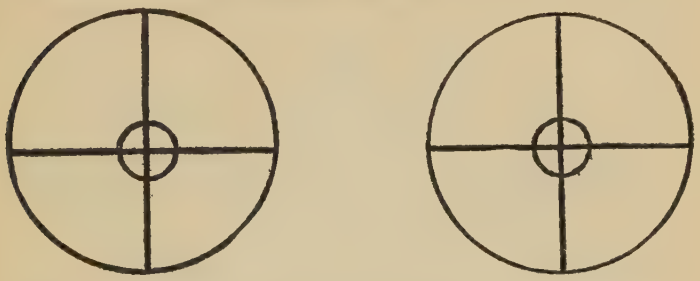


FIG. 19.
Schematic Illustration of the Quadrants of the Visual Field.

Figure 19 represents the quadrants of the visual field. The lingual lobe subserves vision of the upper quadrants of the visual field; the cuneus, the lower quadrants; the calcarine fissure, central vision. Refer to Figure 16 in Chapter 11. The small, inner circle in Figure 19 represents the field of central vision.

A lesion in the lingual convolution (lobe) of the left occipital lobe will produce a right upper quadrant anopsia, see Figure 20, while a lesion of the

FIG. 20.
Schematic Illustration of Right Upper Quadrant Anopsia.

cuneus, in the left occipital lobe, will produce a right lower quadrant anopsia. See Figure 21.

FIG. 21.
Right Lower Quadrant Anopsia.

A destruction of the calcarine fissure, at the extreme pole of the left occipital lobe, will cause a loss of vision in the right half of the field for central vision. See Figure 22. Severe injuries to the occi-

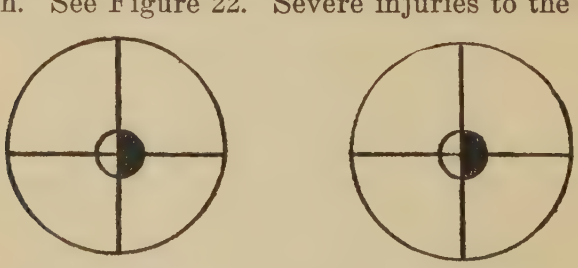


FIG. 22.
Central Blindness. Lesion in left occipital lobe.

put, causing destruction of the occipital lobes near the poles, cause total and permanent blindness. Severe injuries, without destruction of cerebral substance, may cause a total, temporary blindness. Irritative lesions will cause disturbances of vision in the different portions of the visual fields, depending upon the area involved. Such disturbances may

manifest themselves as flashes of light of different colors and forms and moving blind spots. Pressure on the optic chiasm, usually due to tumors of the pituitary body, may cause blindness, or partial blindness. The early result is a bi-temporal anopsia, as the pressure is first applied to the decussating fibres, coming from the nasal portions of the retinae, which control vision of the temporal fields. Injuries, due to severe basal fractures, or perforating gun-shot wounds, may sever the chiasm, causing total and permanent blindness. Pressure, anywhere, on the outer side of the optic nerve, the chiasm or the optic tract will cause disturbance, or loss of vision of the nasal field, which is controlled by the temporal portion of the retina. Pressure on the inner side of the optic nerve, or the optic tract will interfere with the fibres coming from the nasal side of the retina, causing loss, or disturbance of vision of the temporal field. Pressure, anterior and posterior to the chiasm, will interfere with the fibres coming from the nasal portions of both retinae, causing a bi-temporal anopsia. If pressure could be applied to both sides of the chiasm, without producing much pressure on the nasal fibres, a bi-nasal anopsia would result.

The optic nerves, one or both, but usually one, may be severed in severe impact fractures in the frontal region, with the loss of sight of one, or both eyes. In lesions of the optic tract, pupillary disturbances will take place, because the sensory portion of the reflex arc is found in the optic tract.

To summarize, briefly, the importance of the second cranial nerve in locating intra-cranial lesions, the following may be noted: hemianopsia, quadrant anopsia, bi-temporal anopsia, central blindness, pupillary disturbance.

The third cranial nerve, or Oculo-motor, supplies all the muscles of the eye-ball, except the superior oblique and the external rectus, the levator palpebrae superioris, and, through the ciliary ganglion, the sphincter of the iris and the ciliary muscle. It takes its origin from the cerebral peduncle (crus), passes underneath and lateral to the attachment of the posterior clinoid process to the tentorium cerebelli and, passing forward, lies along the lateral wall of the cavernous sinus, entering the orbit by the anterior lacerated foramen. This nerve controls the muscles that enable one to look-upward, downward and inward. (The act of looking downward is assisted by the action of the superior oblique, which is supplied by the fourth cranial, or Trochlear nerve.) The Oculo-motor supplies the muscle that raises the upper eye-lid and the sphincter of the iris.

A lesion that severs, or destroys, this nerve, either at its origin or in its course, will produce a dilated pupil, ptosis of the upper eye-lid and a diverging strabismus, with inability to look upward, downward, or inward. The diverging strabismus (the eye turned outward) is the result of the unopposed action of the external rectus, supplied by the sixth cranial nerve. Such a patient will complain

of diplopia, or double vision, the false image being on a higher level than the true one.

The fourth cranial nerve, or Trochlear, takes its origin from the cerebral peduncle, just above the pons and follows along with the third nerve, lying between it and the ophthalmic division of the fifth nerve on the lateral wall of the cavernous sinus. It enters the orbit by the anterior lacerated foramen to supply the superior oblique muscle of the eye-ball. The action of this muscle is to pull the eye downward and outward.

An injury to this nerve produces diplopia, or double vision, if the patient attempts to look downward, because the eye of the opposite side turns downward while the eye on the affected side remains on a horizontal plane. To overcome this, the patient holds the head forward and inclines it downward and toward the side opposite to the one affected.

The sixth cranial nerve, or Abducens, takes its origin from a nucleus in the fourth ventricle, in the region of the pons, and emerges at the lower border of the pons. It accompanies the third and fourth cranial nerves and, passing through the cavernous sinus on the lateral side of the internal carotid artery, enters the orbit by the anterior lacerated foramen to supply the external rectus muscle of the eye-ball.

This nerve, because of its long course at the base of the skull, is more frequently involved than the others. An injury of this nerve causes the eye-ball to turn inward, or converging strabismus.

Diplopia results. Some of the sympathetic fibres to the dilator pupillae are conveyed along with this nerve, so a moderate contraction of the pupil of the affected side may result, because of a lessening of the opposing pull of the dilator.

The fifth cranial nerve, Trigeminal, or Trifacial, consists of a large sensory and a small motor root. The motor portion supplies the muscles of mastication: the temporal, the masseter, the internal and external pterygoids. The sensory portion supplies sensation to the face, nose, eye, teeth, mouth, palate, pharynx and the anterior two-thirds of the tongue. It is the nerve affected in Trifacial neuralgia. The nuclei of this nerve are found in the aqueduct of Sylvius and the fourth ventricle. It arises by two roots from the side of the pons. The sensory root ends in the Gasserian ganglion, which gives rise to three nerves: the ophthalmic division, which takes its exit from the skull by the anterior lacerated foramen; the maxillary division, which leaves the skull by the foramen rotundum; the mandibular division which passes through the foramen ovale.

A paralysis, involving this nerve, due to severance by a bullet, or shell-fragment, will cause a loss of the corneal reflex and a paralysis of the muscles of mastication on the affected side and loss of sensation in one-half of the face, including the teeth. An irritative lesion, often noticed in fractures of the base, on the other hand, will produce a difficulty

in opening the jaws, due to a spasm of the muscles of mastication, and pain in the eye, nose, face and teeth, all or severally, on one or both sides.

The seventh cranial, or Facial nerve supplies the muscles of expression (the face). It takes its origin from a nucleus in the fourth ventricle near the lower portion of the pons, its fibres passing around the nucleus of the sixth nerve before emerging at the junction of the pons with the medulla. It passes forward and takes its exit by the internal auditory meatus in the petrous portion of the temporal bone, on the anterior wall of the posterior fossa, with the eighth nerve. Its bony course is through the fallopian canal and underneath the floor of the middle ear, to the stylo-mastoid foramen, where it leaves the skull. Due to its long course within the skull-wall, it is very liable to suffer injury in fractures of the base and in wounds involving the external auditory meatus and its immediate vicinity. Fractures of the base, accompanied by facial palsy, often have loss, or diminution of hearing on the same side. In nuclear involvement of the seventh nerve, the sixth is also involved.

The eighth cranial or Auditory nerve arises from nuclei in the floor of the fourth ventricle in the lower part of the pons and the upper part of the medulla. It consists of two distinct portions: the cochlear, which is the nerve of hearing, and the vestibular, which supplies the semi-circular canals and vestibule. This nerve emerges from the upper part of the medulla and passes through the internal audi-

tory meatus. It is the only cranial nerve that does not leave the skull. Injuries to this nerve cause loss of hearing, if destructive. If irritative, they may cause diminution of hearing and give rise to "buzzing in the ear" and dizziness.

The ninth cranial or Glosso-pharyngeal nerve originates from nuclei in the fourth ventricle in the medulla and arises from three or four roots, which leave the medulla to form the nerve, which takes its exit from the skull by the posterior lacerated foramen. It supplies the mucous membrane of the fauces, the base of the tongue, the mouth and tonsil.

The tenth cranial, Vagus, or Pneumogastric nerve originates from nuclei in the floor of the fourth ventricle in the medulla and arises by eight to ten roots, attached to the medulla, and takes its exit by the posterior lacerated foramen. It has a ganglion and communicates with the seventh, ninth, eleventh and twelfth cranial nerves the first and second cervical nerves and the symphathetic. It supplies the meninges, the skin of the back of the external ear, the pharynx, larynx, trachea, lungs, heart, oesophagus, stomach (the left vagus supplies the anterior surface of the stomach and the right, the posterior surface), the liver, pancreas, spleen, kidney, supra-renal body and intestine.

This nerve may be severed in gun-shot or incised wounds of the neck. The symptoms are: tachycardia, retching and vomiting, and slow respiration, with a sensation of suffocation. Fatal injuries, due

to fracture of the posterior fossa, or gun-shot wounds below the tentorium (lower occipital region), are due to cerebral edema, with its resulting compression of the medulla, containing the nuclei of this nerve. Injuries, in this region, causing instant death, directly involve these centers.

The eleventh cranial, or Spinal Accessory nerve consists of two portions: a cranial portion, called the accessory portion, which originates from the nuclei in the floor of the fourth ventricle and takes its exit by the posterior lacerated foramen to communicate with the pharyngeal and superior laryngeal branches of the vagus and to supply the muscles of the soft palate; the spinal portion, which arises by filaments from the upper spinal cord behind the anterior roots of the upper five cervical nerves, to form the spinal portion of the nerve, which enters the skull by the foramen magnum and leaves the skull, again, by the posterior lacerated foramen to communicate with the second, third and fourth spinal nerves and to supply the sterno-cleido-mastoid and trapezius muscles.

The twelfth cranial or Hypoglossal nerve originates from nuclei in the lower part of the medulla, in the floor of the fourth ventricle, and arises by ten to fifteen roots from the lower portion of the medulla and takes its exit from the skull by the anterior condyloid foramen. It supplies the muscles of the tongue. Isolated paralysis of this nerve may occur in fractures of the posterior fossa. Such a patient, asked to protrude the tongue, will deviate

the tongue toward the paralysed side. On retracting the tongue, the paralysed side bulges upward. The patient has difficulty in talking, swallowing and in the mastication of food.

Chapter IV

INJURIES TO THE SCALP

All injuries to the head, no matter how trifling they may seem at first sight, should be considered as serious, providing the impact has been severe, or the injury is due to a gun-shot wound. All scalp wounds should be excised and the instruments, used in the excision, discarded. Three legged, or tripod incisions (see Chapter VII), radiating from the defect left in the scalp by the excision, with undermining of the flaps, will permit of a thorough inspection of the underlying skull and facilitate closure of the scalp. The use of these incisions may enable the operator to close rather large defects.

When we recall that the venous diploe of the skull communicate with the veins in the scalp and, so, allow a communication of the veins in the scalp with the longitudinal sinus, the importance of excising infected and devitalized scalp will be recognized. In the first instance, the scalp is already infected; and, in the second instance, devitalized scalp may slough, or heal poorly, favoring a secondary infection. Because of the rich blood supply of the scalp, healing is very rapid, when the healthy tissues are approximated. To control hemorrhage, rat toothed forceps should be attached to the galea and the handles depressed in the direction away from the

wound. Do not attempt to grasp the bleeding vessels in the scalp, because the spongy nature of its make-up allows the forceps to tear out. Only in such cases, where the vessel, itself, may be easily grasped by the forceps and ligated, as the temporal artery, should this be done. By placing strips of sterile gauze through the loops of the handles of the forceps, the gauze strips may be fastened to the sterile sheet by forceps, or held by the assistant, serving the purpose of a simple and effective retractor. The skull, following excision of the scalp wound, should be swabbed with ethyl alcohol, whether or not a fracture exists, before making the tripod incision. If the skull is found to be intact, the three incisions, radiating from the defect, are made and the three triangular flaps undermined by separating the galea from the pericranium. This permits of pulling the peaks of the triangular flaps into apposition with one another, without undue tension. It may be necessary to trim them slightly with a sharp pair of scissors. The galea, at these points, is united by silk, or No. 00 interrupted chromic gut sutures. When this has been accomplished, the galea in the legs of the incision are united in the same manner. The scalp is closed by interrupted silk sutures, which should be removed on the third or fourth day, if the wound is found to be clean.

In slight injuries of the scalp, an area about the wound should be shaved. If the slightest suspicion exists, regarding the seriousness of the injury, the

entire head should be shaved. It is better to shave the head, without clipping, to prevent the clinging of short hairs to the scalp. If the head is clipped, it should be thoroughly washed with tincture of green soap and sterile water, using sterile, absorbent cotton to wipe off the head, following with the direction of the growth of the hair. This will, most effectively, remove the short hairs. After shaving, the scalp is sponged and wiped with ethyl alcohol to remove the soap and water. After being wiped dry, it is sponged with benzene, followed by alcohol and ether. The scalp is, then, ready for the injection of novocain solution, if a local anaesthetic is used. Sterile towels are draped about the operative field and fastened to the scalp by skin clips.

FIG. 23.
Tripod Incision.

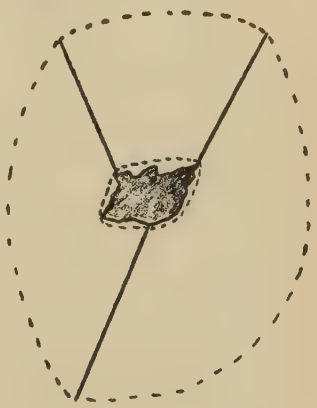


FIG. 24.
Tripod Incision.

Figure 23 illustrates the three-legged, or tripod incision. The shaded portion represents the defect in the scalp and the dotted line about it indicates

the area involved in the excision. The dotted line, surrounding the larger area, represents the area involved in undermining the galea. Figure 24 represents a defect of different form in which the tripod incision is used, while Figure 25 represents the

FIG. 25.
Closure of Tripod Incision.

closure at the points of apposition. Note that the two lines, to the left of the observer, become one angled line, bringing a part of the defect together, like the closing of a pair of pincers.

FIG. 26.
Linear Incision.

Linear, incised wounds of the scalp should be treated as represented in Figure 26.

If the defect is large, closure is facilitated by making a knee or angle in each one of the three

FIG. 27.
Angled Tripod Incision.

incisions (see Chapter VII) Figure 27 represents this incision used in a large defect. Figure 28 represents the closure at the approximating margins. When final closure has been effected, the angles become more or less curved. The lines in Figure 28 are represented as angled in order to not confuse the reader.

In very large defects of the scalp, it is necessary to prepare flaps, using zigzag incisions, in order to permit of a greater elongation of the flaps. In doing this, it may be necessary to leave portions

FIG. 28.
Closure of Angled Tripod Incision.

of the intact skull exposed. These defects are allowed to granulate. If grafting should become necessary, it leaves a much smaller total area to cover and insures better nourishment for the graft. Do not attempt to suture in cases, where the tension at the lines of suture is great, as such attempts invariably fail.

Large defects of the vault are particularly difficult to cover. The need for covering such a defect is imperative in wounds in which a defect of the skull and dura exists. Figures 29, 30, 31, 32, 33, 34, 35 and 36 illustrate the use of zigzag incisions in securing flaps to effect closure of a large defect of the vault.

The large scalp wound is first excised. Defects of this kind usually have extensive fractures. As a rule, these should not be disturbed, unless an attempt is made to control hemorrhage from a lacerated longitudinal sinus. This is best done by enlarging the defect, with rongeurs, sufficiently to permit of a removal of the depressed bone fragments. The hemorrhage from the rent in the sinus may readily be controlled by placing a piece of peri-cranium, turned outside in, over the rent in the sinus, or by ligation. If the sinus is ligated on both sides of the rent and a large defect exists in the dura, the dural defect is filled in by a piece of fascia lata, to which a thin layer of fat is allowed to remain attached, turning the fat side inward. A defect in the dura, on one side of the sinus, may exist and a thrombosis may be present in the sinus, underneath the bone fragments. When these are disturbed, a fresh hemorrhage usually results, necessitating ligation, with removal of the injured portion, making the dural defect larger.

A zigzag incision is made on the right side in front of the ear and a little above its attachment to the skull, the last leg extending above the ear. Similar incisions are made over the right occipital region. At the anterior end of the anterior incision, already mentioned, an incision is carried to the right anterior corner of the defect. From a point one inch above one of the peaks of the posterior incision, a vertical one is made to the right posterior

corner of the defect. On the left side, the anterior incision is made from the left anterior corner of the defect down to the zygoma and a zigzag incision, made behind the ear, extending onto the lower occiput and carried up as a straight incision to the left posterior corner of the defect. Another short zigzag incision is made over the left occiput. The two lateral flaps and the posterior flaps are, then, undermined and, where the edges come in apposition without tension, they are united by two layers of interrupted silk sutures: one in the galea and the other in the scalp. The right flap can be brought up at both ends, with a little more slack, anteriorly and posteriorly, with its greatest limitation of stretch at the center. The left flap is liberal posteriorly, the amount of slack gradually lessening anteriorly. A certain amount of slack is obtained in the posterior flap by the short zigzag incisions over the lower occipital region.

When the possibility of closing the defect by this method is questioned, both sides should be treated as by that method described for the left side, except, that the position of the incisions on the right side are reversed. This gives a flap on the right side, with its greatest slack anteriorly and that on the left side with its greatest slack posteriorly. If the defect in the skull is very large, this method is preferable to the former, as a more effectual closure of the vault area is made possible.

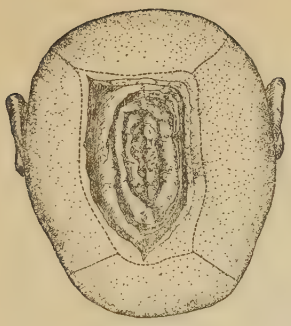


FIG. 29.

FIG. 30.

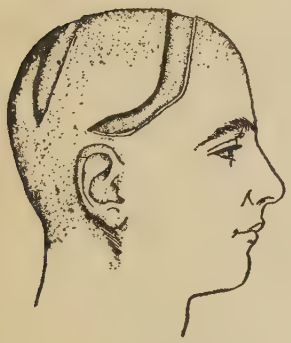


FIG. 31.

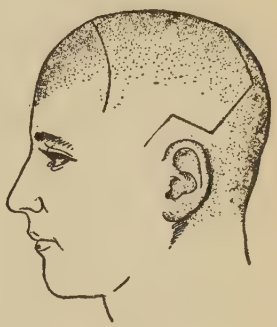


FIG. 32.

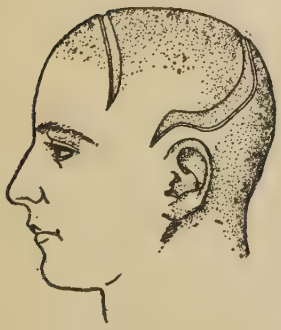


FIG. 33.

FIG. 34.

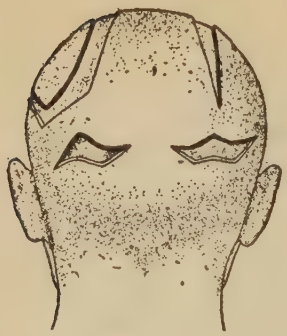


FIG. 35.

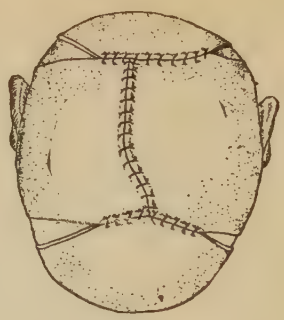


FIG. 36.

Figures 29, 30, 31, 32, 33, 34, 35 and 36 illustrate the various steps in the first method described. Figure 36 illustrates the closure of the vault. The other defects, shown in the other illustrations are not

FIG. 37.

Fig. 38

sutured. Figure 37 illustrates the appearance of closure over the vault and Figure 38 the denuded areas on the right side of the head, when the latter method is used. If necessary, short zigzag incisions may be made in the large flaps, at some distance from the skull defect, when they do not seriously interfere with the blood supply, wherever the great-

est slack is required to relieve tension at the line of suture. By these methods, the defect may be covered, affording a protection for the dura and brain against the invasion of infection, even though intact portions of the skull are denuded. In a remarkably short time, these flaps become adherent to the skull, so that, in cases where it later becomes necessary to insert a drain, it requires a forceps and some force to establish a drainage opening beneath them for the insertion of rubber tissue. The defects over the intact skull should be kept moist by dressings saturated with Dakin's solution.

A hematoma, underlying the scalp, should be incised, if a fracture is suspected. Circular, depressed fractures, in which the external table is only slightly depressed, may pass unnoticed, if one is forced to depend upon palpation for a diagnosis. These injuries, complicated by circular, depressed fractures, are, particularly difficult to recognize in the occipital region and when located at, or near, the pole of the occipital lobe may cause partial, or complete loss of vision, hence, the importance of recognizing such a condition as early as possible.

Chapter V

FRACTURES OF THE SKULL

Fractures of the skull may result from direct, or indirect violence. Those, due to direct violence, may be caused by falls, or by being struck by moving objects. Fractures of this nature may appear as simple fissures in the skull, depressed fractures, or perforations of the skull. Depressed fractures occur with and without perforation of the dura. Those, in which the dura is perforated, often have pieces of inner table driven into the brain.

Fractures due to indirect violence, as falls in which the individual alights on the feet, knees, or buttocks, are commonly known as basal fractures. In basal fractures, the middle fossa is most commonly involved as well as its junction with the frontal and posterior fossae. Blows on the chin, or falls, striking on the point of the chin, may produce fracture, involving the middle fossa on one or both sides only. Severe fractures of the base, usually involve the posterior fossa as well. Crushing injuries of the head, compression fractures, with either side of the head dependent, usually involve all the fossae.

The common signs in basal fracture are hemorrhages from the nose, mouth and one, or both ears. This is, perhaps, the most common and easily recog-

nized fracture in civil life. Severe basal fractures, involving the posterior fossa are, often, instantaneously fatal. While this type of fracture is usually recognized early, especially, in those cases in which hemorrhage from the nose, mouth and ears occurs, the proper treatment of each individual case offers the greatest difficulties. Basal fractures, accompanied by hemorrhage from the nose, mouth and ears, have a certain amount of decompression, as the escape of blood prevents the compression caused by intracranial hemorrhage, where there is no outlet. If no cerebral edema, or only a moderate cerebral edema, should occur, the brain would tolerate the pressure, caused by the hemorrhage, in most cases. What, then, is the proper treatment for these cases? Each case is a law unto itself. Extensive basal fractures may recover without operation, while others, less extensive, will die, unless a decompression is brought about in time. A basal fracture should be brought to a hospital as soon following the injury as possible, there to remain until the danger is past. Care should be taken to keep the nose, mouth and ears clean. The ear may be gently swabed with sterile cotton, the canal filled with ethyl alcohol and a small piece of sterile cotton loosely placed in the meatus. The nose may be gently irrigated with dilute Dakin's solution, turning the head to the side and allowing the fluid to run out of the mouth and the other nostril, if it will. The mouth should be kept open by placing a piece of solid rubber, to which a string is attached,

between the teeth. The patient should be kept quietly in bed, with the room darkened and with the attendance of a nurse, only. A lumbar puncture should be done and the intra-spinal pressure determined. If the intra-spinal pressure is found to be as high as 12 mm. of mercury, another puncture should be done within an hour and, if found to be rising, a sub-temporal decompression, on the right side in right handed individuals and vice versa, should be done, without further delay. It has been the writer's experience, that in severe fractures of the base, cerebral edema develops rapidly and, therefore, he always follows this rule. In less severe injuries, or in injuries, involving other parts of the skull, the writer allows the intra-spinal pressure to reach 14 mm. of mercury and, then, if found to be rising, he performs a subtemporal decompression. (See Chapter VI). In cases of basal fracture, in which there is no hemorrhage from the nose, mouth, or ears and the spinal puncture reveals a bloody cerebro-spinal fluid with a pressure of over 12 mm. of mercury, a sub-temporal decompression should be done. Do not wait for the rapid pulse to become abnormally slow, which is accompanied by slow or Cheyne-Stokes respiration, for then the cerebral edema is well under way and operation is useless. If you want to save your patient, do not neglect the lumbar puncture. If no mercury manometer is at hand, a spinal puncture will reveal increased pressure, as the cerebro-spinal fluid will shoot out from the needle in a stream. Cerebro-spinal fluid that drips

from 16 to 30 drops per minute may be under normal pressure.

Great caution should be exercised in performing lumbar puncture. No more than 3 to 5 c. c. of fluid should be withdrawn at any single puncture, early following the injury, and, then, it is better to do so with the foot of the bed slightly elevated.

In cases, with other injuries and where shock is present, place hot water-bags about the patient and restore body heat. Hot black coffee, or hot tea, may be given by mouth. If such a patient does not recover from shock, there is no need of adding another operated head injury to the list of operative mortality.

Since the introduction of the automobile, impact fractures, or fractures due to direct violence, have greatly increased in civil life. Of these fractures, frontal fractures are most common. Frontal fractures, caused by these injuries, usually pass through both orbits, the articulations of the nasal bones and vomer with the frontal bone and through the zygomatic process of both malar bones. The frontal sinus, ethmoid, sphenoid and the frontal bone are usually involved. Sometimes such fractures only involve one side, one fracture passing obliquely downward, leaving one maxillary and malar bone, the nasal bones and one orbit intact. Fractures of this type require especial attention to two details: the cleaning up of the injury involving the brain, for, if the patient dies, all other work is of no avail; the immobilization of the upper jaw, after the teeth

have been brought into normal articulation with their fellows in the lower jaw. This latter point cannot be too strongly emphasized, for, without immobilization of the upper jaw, the cranial cavity is permitted to communicate with the outside world through cavities, already septic, over an extended period of time, with the inevitable result that infection gains entrance to the cranial chamber. This immobilization is best brought about by the use of a four tail

FIG. 39.
The Four-tail Bandage.

bandage. See Figure 39. The tails marked "1" are tied behind the head; the tails, marked "2", are, at first, pulled back so that the central portion of the bandage is brought over and under the chin, when the tails are pulled upward and tied at the top of the head, over a heavy, folded towel and tails 1 and 2 tied together to prevent their displacement. Much force must be used in tying the tails of the bandage in order to immobilize the lower jaw, which acts as a perfect splint. The patient is fed liquids through a tube, taking care to furnish the required amounts of water, proteins, carbohydrates and fats. In fractures of this type, in which only one side of the upper jaw is involved, it is the practice of the writer, in conjunction with a Dental Surgeon, to wire the teeth in addition to the use of the four tail bandage.

If no teeth exist, or the number of teeth are too few and scattered to permit of this procedure, an impression of the upper jaw is taken and a vulcanite splint prepared, allowing for an artificial process of vulcanite to fit into the articular surfaces of the teeth of the lower jaw, or over the gum of the lower jaw, when the inside vulcanite splint is brought into place and the four tail bandage applied as already described. This method is very simple and the most comfortable for the patient. Perforations in the vulcanite splint allow for the sucking in of the liquids. The writer has found this method, in his hands, to be the best in the results attained.

To briefly summarize: the cranial chamber must be closed in order to prevent subsequent infection and this is accomplished by the operation on the head and the immobilization of the upper jaw—one just as important as the other and either one, a failure without the other. Insert Figure 40 is a photograph of a patient, with a frontal fracture and a complete separation of the upper jaw from the rest of the skull, showing the use of the four tail bandage. In complete transverse fractures of the face, the teeth are not wired, as any attempt on the part of the patient to open the jaw will tend to displace the fracture.

Inserts Figures 41, 42 and 43 are photographs of a severe frontal fracture, with a loss of a large portion of the right frontal lobe and a separation of the right maxillary bone from the skull. Almost the entire bony orbit was destroyed with the loss of the

right eye. Figure 41 shows how the wires are left long, twisted and brought out of the mouth. Short wires should not be used, as any attempt to twist them with pliers will often break them and the short ends cause no end of discomfort to the patient. When allowed to protrude through the lips, they cause no discomfort. Figure 42 shows the use of a solid silver plate, worn beneath the bandage to prevent bulging in this case. Figure 43 is a photograph of this patient on the 28th day following the injury. This case was operated upon two hours following the injury. This case will be operated upon for skull repair, with restoration of the orbit.

In impact fractures, where the bone is depressed, trepanation of the skull should be done, with removal of the bone en bloc, except, in the frontal and lower occipital regions, where the skull is very thick and as small a defect, as possible, is desired. When a depressed fracture is over a sinus, trepanation should always be done in order to render easy the control of any possible hemorrhage from the sinus. By trepanation of the skull is meant the removal of a piece of bone en bloc. This is usually done by drilling three holes in the skull, about a fracture, and cutting between them with a De Vilbis, or Montevnosi linear bone cutting forceps. The bone is lifted out en bloc. Four or five holes are preferable, when, by cutting out a quadrangular or pentagonal piece of skull, the defect may be smaller. For this purpose a drill should be used. The obsolete trephine should never be used. There are three very

good drills on the market: the Hudson drill, which is a good drill for one not familiar with this work, as it is practically fool-proof, but has the disadvantage that it is very slow to operate: the Doyen drill and a drill put out by Chas. Willms and Company. The writer uses the Willms drill, equipped with one-half inch burs, made according to his own instructions. This drill is very rapid, but care must be used to avoid perforating the dura.

When a mental picture has been drawn, in the operator's mind, regarding the form of trepanation: triangular, quadrangular, or pentagonal, the knife-point drill is first used to perforate the external

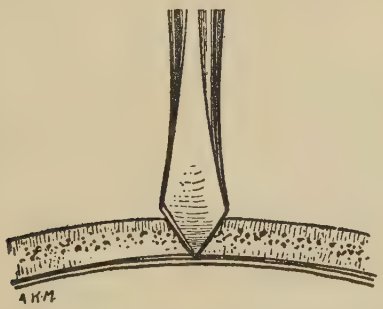


FIG. 44.
Illustrating the use of the perforator or knife-point drill.

table. See Figure 44. This is followed by the bur

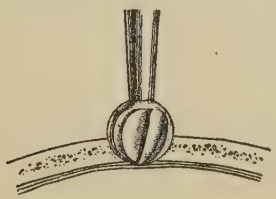


FIG. 45.
Illustrating the use of the bur.

down to the dura. See Figure 45. The remaining pieces of internal table, at the bottom of the drill-hole, are, then, removed by a dural separator and bone elevator for craniotomy. See Insert Figure 46. The blade of this instrument is placed beneath the bone, rotating the handle between the thumb and forefinger, separating the dura from the bone well beyond the margins of the opening made by the drill. The use of this instrument permits the introduction of the linear bone cutting forceps without injuring the dura. The bone cutter is now introduced and the holes, made by the burs, united by linear cuts.

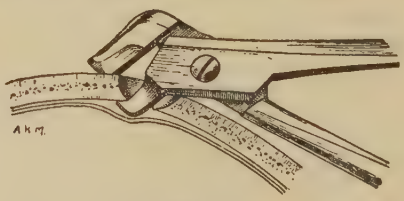


Fig. 47

Illustrating the use of the Montevnosi linear bone cutting forceps.

See Figure 47. Figures 48 and 49 are photographs of external and internal aspects of a depressed fracture removed en bloc.

If the case is brought in late and infection is present, with thickening and friability of the dura, hemorrhage from the dural vessels may be controlled by applying small silver clips. See Figure 50. The instruments for making and applying these clips were originated by Dr. Harvey Cushing. A fine silver wire is wound about a specially designed post and cut by a pair of scissors on both sides of

FIG. 40.

Fracture of the base of the skull with complete transverse fracture of the face, illustrating the use of the four-tail bandage.

FIG. 41.

Illustrating the use of the four-tail bandage and long wires, which hold right maxillary bone firmly attached to the intact left maxillary bone, protruding from mouth.

FIG. 42.
Illustrating the use of a silver plate to prevent excessive bulging.

FIG. 43.
Appearance of severe frontal fracture 28 days following injury.

FIG. 46.

Dural Separator and Bone Elevator for Craniotomy. (Hanson.)

FIG. 48.
Photograph of bone removed en bloc (external aspect).

FIG. 49.
Photograph of bone removed en bloc (internal aspect).

FIG. 51

Illustrating the winding of silver wire about specially designed post preparatory to cutting along lateral grooves to make clips. (Cushing).

FIG. 52.

Illustrating the removal of clip by clip-holder (Cushing).

FIG. 53.

Photograph of clip holder with clip ready for application to vessel. (Cushing).

FIG. 54.

Cushing's Esquillectomy Forceps.

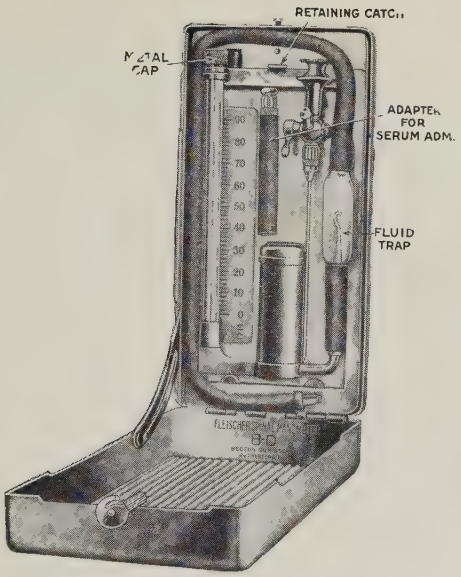


FIG. 55.

The Fleischer Spinal Manometer (Improved).
(Becton, Dickinson & Co.)

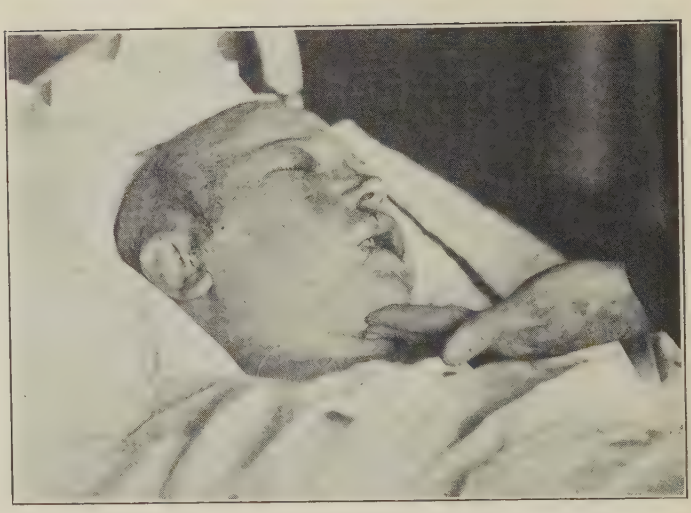


FIG. 58.

Sub-temporal decompression on the third day when the stitches were removed.

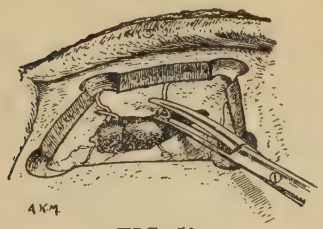


FIG. 50.

Illustrating the application of silver clips to dural vessels.

the post, along the groove, facing the observer as shown in Insert Figure 51. The clips are then placed on a post, notched for the reception of each individual clip and covered by a metal case that keeps them in place. The post is gradually withdrawn from its sheath allowing the operator to grasp the clip with the clip-holder, designed for this purpose. See Insert Figure 52. The clip-holder, with clip ready to be applied, is shown in Insert Figure 53.

If pieces of bone are driven deeply into the brain, a soft-nosed, medium sized rubber catheter is passed through the opening in the dura and into the brain, serving the purpose of an artificial finger in locating the foreign bodies. As they are located, they are removed by Cushing's esquillectomy forceps. See Insert Figure 54. This is a delicate angle forceps, the ends of which have small, round, concave, perforated surfaces, corrugated on the inner concave surfaces for the purpose of grasping foreign bodies.

In large depressed fractures of the parietal region, it is better to rongeur away enough of the margins of the defect in the skull to permit of easy elevation of the bone.

It must be born in mind that impact fractures may require a sub-temporal decompression, if a cerebral edema is threatened. Large fractures of the vault should be closely watched. A lumbar puncture should always be made to determine the intra-spinal pressure, if indicated.

All fractures of the skull should be kept in bed; no visitors allowed; morphine, in liberal doses, to insure quiet; light nourishing food and an enema should be given every day. The patient should be encouraged to take liberal quantities of water, with occasional doses of citrocarbonate, or other alkalies, dissolved in the drinking water.

Chapter VI

INJURIES TO THE BRAIN

It must be born in mind that in dealing with head injuries we are often face to face with a rapidly increasing intra-cranial pressure. While no examination for brain tumor is complete without an examination for choked disk, this condition is rarely seen in head injuries, except, in those cases where the patient survives for sometime and the pressure is due to a slow intra-cranial hemorrhage, or a cerebral edema. The increased pressure in injury cases should always be determined by lumbar puncture and the use of the mercury manometer. See Insert Figure 55.

It has been stated and taught that the normal intra-spinal pressure is 40 to 100 mm. of water, or 12 to 20 mm. of mercury. The writer has never found the intra-spinal pressure in an individual with a blood-pressure of 120 to 130 mm. of mercury to exceed 10 mm. of mercury. It is difficult to state the exact normal intra-spinal pressure as intra-spinal pressures are not taken in perfectly normal individuals. The writer considers the normal pressure as anywhere between 6 and 10 mm. of mercury, with 10 mm. as the upper normal limit. Sharpe, after an exhaustive study, has stated the normal pressure to be 5 to 9 mm. of mercury in the adult and 4 to 8 mm. in children.

In shock, in which the blood-pressure falls, the intra-spinal pressure is lowered. During operations on the brain, or in operations for severe head injuries, the blood-pressure should be constantly watched. If the systolic pressure falls below 90, the operation should be discontinued, leaving a decompression and closing the scalp in two layers with interrupted sutures. This is a case in which it is better to run away and live to fight another day. The only exceptions to this rule are the cases in which it is imperative to control hemorrhage from the middle meningeal artery or a blood sinus.

The technique, used by the writer in performing lumbar puncture, is as follows: the patient is turned on the right side and the body sharply flexed, bringing the head and knees together and the exposed back to the edge of the bed. The site for puncture is between the fourth and fifth lumbar vertebrae in the middle of a line uniting the upper limits of the iliac crests. A spot four inches square is painted about this area and over it, as well as the thumb and fore-finger of the left hand of the operator, using a 10 per cent tincture of iodine. The left thumb is used to identify the space between the two spines, steadying the hand with the left-forefinger. A sharp bistoury is, then, used to make a puncture in the skin to the left of the spot indicated by the left thumb and the needle shoved upward and toward the mid-line of the spine. If cerebro-spinal fluid appears on withdrawing the stylette, the stylette is immediately replaced and the patient tilted in such

a manner as to bring the needle on a horizontal plane. The mercury manometer is, then, quickly attached, after withdrawing the stylette. The intracranial pressure, being accurately determined, the valve in the spinal puncture needle is turned so as to direct the flow of the cerebro-spinal fluid into a small graduate. From 3 to 5 c. c. may be withdrawn (never more than 5 c. c.) to determine cell count, blood and whatever tests might be indicated. Some prefer to make the spinal puncture through the mid-line, or to the right of the mid-line, but the method, already described, is the easiest in making a spinal puncture in the adult. Sometimes, it may be necessary to make the puncture between the third and fourth lumbar vertebrae when one fails to secure fluid between the fourth and fifth.

Normal cerebro-spinal fluid resembles the clearest water. It has a specific gravity of 1.004. A few cells are present in normal cerebro-spinal fluid, but never more than eight to twelve per cmm. The normal cells are of two types, small and large mononuclear cells, the small mono-nuclears predominating. Polymorpho-nuclear cells are never found in normal cerebro-spinal fluid, unless contaminated with blood. The normal amount of cerebro-spinal fluid in the adult is 80 to 120 c. c. and is said to be replaced six or seven times every twenty-four hours. It is very rapidly replaced, if lost.

In cases that recover slowly from head injury, it is well to determine the following facts: excessive

protein content, the sugar (dextrose) content, cerebro-spinal fluid and blood Wassermann.

The tests for excessive protein content, that are the simplest and most easily made, are the Nonne Apelt and Ross-Jones tests. In the former, 1 c. c. of a saturated solution of ammonium sulphate is added to 1 c. c. of cerebro-spinal fluid. A marked cloudiness indicates an excess of protein. In the latter, the cerebro-spinal fluid is allowed to flow gently on top of the saturated ammonium sulphate solution in a test-tube. A white ring at the junction of the two fluids, indicates an excess of protein.

The normal dextrose content of the cerebro-spinal fluid is 0.04 to 0.05 per cent. Normal cerebro-spinal fluid will reduce Fehling's solution. In acute meningitis and syphilis, the dextrose content is decreased.

1 c. c. of cerebro-spinal fluid reduces 2 to 2.3 c. c. of deci-normal potassium permanganate solution when rendered slightly acid and boiled. In tubercular meningitis, 1 c c. of cerebro-spinal fluid will reduce 3 to 6 c. c. of deci-normal potassium per-manganate solution. This is called the Mayerhofer Reduction test.

Patients with recent syphilitic infection may have a lighting up of this condition in the brain. Such patients may become very violent, or resemble an encephalitis. These cases are best treated by injecting Neo-Salvarsan directly into the lateral ventricle. Cerebro-spinal fluid and blood Wassermann tests will clear up the diagnosis.

In infections of the meninges, or brain, the staphylococcus is often present, even when other organisms are, directly, the cause of the condition. The bacteria that may be found in such conditions are: the staphylococcus, the streptococcus, the meningococcus, the pneumococcus, the bacillus of influenza, the tubercle bacillus and the spirochete.

In culturing, the best media are blood agar and Loeffler's blood serum. It is better to use large amounts of cerebro-spinal fluid (1 c. c.). Cultures from cerebro-spinal fluid should always be made immediately following spinal puncture, while the fluid is still warm. The staphylococcus is not difficult to recognize. The meningococcus resembles the gonococcus in appearance, is intra and extra-cellular and stains in the same way (gram negative). The pneumococcus is larger than the meningococcus; is gram positive and is difficult to differentiate from the streptococcus as both occur in short chains and are both gram positive. The pneumococci appear as double chains and are lancelate in form. In good stains, a capsule may be distinguished surrounding the two cocci. A pure pneumococcic infection of the meninges and brain is particularly fatal, as is the one due to the streptococcus, especially, in which the streptococci occur in short chains. The bacillus of influenza is a small slender bacillus, which hugs the leucocyte.

Do not attempt to culture the tubercle bacillus or the spirochete. In testing for the tubercle bacillus, allow the cerebro-spinal fluid to stand in the

test-tube until the coagulum separates out. Tease out the cloudy coagulum with fine needles on a glass slide, dry, fix and use the Ziehl-Nielsen stain. In order to have a positive proof to verify the diagnosis, the freshly drawn cerebro-spinal fluid may be injected into the inguinal region of a young guinea pig. As low a content as 5 or 6 tubercle bacilli will produce tuberculosis in young guinea pigs, which are very susceptible to tuberculosis.

If it is desired to check the Wassermann, especially, when the test is doubtful, the warm cerebro-spinal fluid may be slowly injected into the testicle of a rabbit. After three or four weeks, sectioning and examination of the stained section will reveal numerous spirocheta in the syphiloma.

The examination of a severe head injury must often be made hurriedly, as to procrastinate spells doom for the patient. First, determine from the appearance of the injury as to its location and possible severity. Determine, if in shock. If the skin is cold and clammy, the pulse rapid and weak, apply external heat, administer hypodermics of camphorated oil and give strong black coffee, either by mouth, or as an enema. If the coffee is given by mouth and the patient vomits, follow immediately by an enema of strong, black coffee. Do not give more than 240 c. c., as to give a larger amount is liable to cause evacuation. Watch the patient closely, taking pulse and blood-pressure from time to time. If the patient recovers from the shock, perform lumbar puncture and determine the intra-spinal pres-

sure and whether or not the cerebro-spinal fluid is bloody. If the intra-spinal pressure is found to be 14 mm. of mercury, allow the manometer to remain attached for a few minutes and, if the pressure is seen to slowly increase, perform a sub-temporal decompression on the right side in right handed individuals and vice versa without further delay, regardless of the location of the injury and whether or not a depressed fracture exists, even though it be a large depressed fracture of the vault. Large depressed fractures may be elevated in a day or two, or as late as one week following the injury, depending upon the condition of the patient. (See Fractures of the Skull.)

Should the pressure be found to be below 14 mm. of mercury, a neurological examination may be attempted. Look at the eyes. Is there a diverging, or a converging strabismus? Are the pupils dilated, or is one pupil larger than the other? Very often a frontal injury will have a dilated pupil on the side of the injury. (See Chapter III.) Is the knee-jerk exaggerated on one or both sides? Is a Babinski present on one or both sides? A Babinski is a slow hyperextension of the great toe elicited by stroking the sole of the foot, the inside of the leg, or by grasping the calf of the leg, suddenly and firmly. Is there spasticity on one, or both sides? Are the respirations abnormally slow, or Cheyne-Stokes in character?

If spasticity, increased knee-jerk and a Babinski are found on the right side, the lesion, or hemorr-

hage, is in, or over the left hemisphere and vice versa. If the respirations are Cheyne-Stokes in character, the patient has an advancing cerebral edema. It is a bulbar symptom. In cases, with high intra-cranial pressure, giving rise to bulbar symptoms (dilatation of the pupils is one of them), hyperpyrexia may be present. In one case, operated upon by the writer, a depressed fracture of the vault in which a right sided decompression was done and the depressed bone removed, the temperature reached 110 degrees Fahrenheit (rectal) and the case recovered. This case had a bulging defect and a spastic paraplegia, but following a costochondral graft to repair the defect in the skull, walks very well and is quite normal.

Do the toes turn in? This condition, accompanied by spastic paraplegia, occurs in thrombosis of the longitudinal sinus. This is due to interference with the cerebral veins draining the motor areas and which enter the sinus. This spastic paraplegia, with a turning in of the toes, is called the Sargent-Holmes Syndrome, because first described by Colonels Sargent and Holmes of the British Army, during the World War.

Many head injuries, when brought to the attention of the surgeon, are either unconscious, or irrational. One must depend entirely upon objective signs and symptoms. Patients with severe injuries, involving the occipital lobes, may be blind. This blindness may be partial, or complete, even though the skull is not fractured. In depressed fractures

of the occiput, it is urgent to remove, or elevate the depressed bone as soon as possible. If the lesion is not destructive, or only partially destructive, sight may be restored completely or partially. If the depressed bone is not elevated, or removed, a progressive softening may take place, with a permanent total loss of vision as the result. (See Chapter II.)

The Sub-temporal Decompression.

Two types of incisions may be used in performing sub-temporal decompressions, taking care to incise the temporal muscle below its attachment to the skull. One is the curved incision, commencing at the hair line in the fronto-temporal region and ending at the zygoma in front of the ear, with its con-

FIG. 56.
Illustrating the curved incision for sub-temporal decompression.

vexity upward and backward. See Figure 56. The temporal muscle is cut in the same way and the muscle separated from the skull, turning the flap of scalp and muscle downward and forward.

The other is the linear incision, which is started at a line drawn perpendicular to the external auditory meatus and carried downward in a forward direction to end at the zygoma in front of the ear. This incision is in the direction of the fibres of the temporal muscle. The temporal muscle is split down to the skull, taking care to start the incision in the temporal muscle and its fascia, below its attachment to the skull, so as to render accurate closure possible. If the muscle is cut at its upper attachment, it will be found to be impossible to close the upper

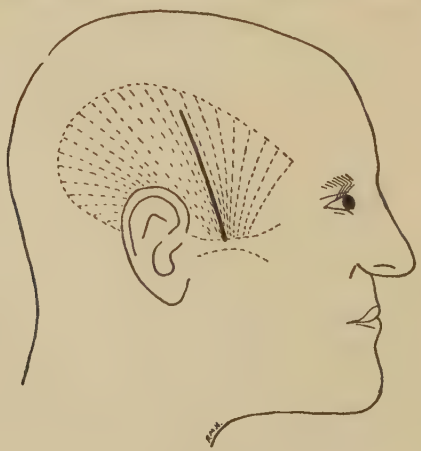


FIG. 57.
Illustrating the linear incision for sub-temporal decompression.

portion. See Figure 57. The split muscle is separated and kept so by the use of a self-retaining retrac-

tor. A knife-point drill, or perforator, is then used to perforate the external table and followed by a large bur down to the dura. The opening in the skull is then enlarged to the desired size by the use of rongeurs. The bone should be removed well down toward the base.

Regardless of the type of incision used, the dura is opened by a curved incision, at a short distance from the margin of the skull defect, with its convexity upward, ligating the branches of the middle meningeal artery with fine silk. The retractor is removed and the muscle closed by interrupted No. 00 chromic gut sutures and the fascia of the temporal muscle, by interrupted silk sutures. The scalp is closed by interrupted silk sutures, which are removed on the third or fourth day. See Insert Figure 58.

Occasionally, a sub-temporal decompression may not be sufficient to relieve the cerebral edema completely, or such cases may occur, as has been the writer's experience, in which, for some unaccountable reason, the cerebral edema may recur, or become aggravated as late as one week after the decompression has been done. The surgeon then has the choice of one of three things: allowing the patient to die, performing a sub-temporal decompression on the opposite side, or a large osteoplastic decompression on the same side. The last mentioned procedure is the best, for to do a subtemporal decompression on the opposite side may cause loss of speech, or interfere seriously with

speech. Furthermore, a large osteo-plastic flap decompression offers the largest possible decompression, without leaving a skull defect.

A large osteo-plastic flap decompression is simply the turning down of a large osteo-plastic flap and a dural flap and replacing the bone without suturing the dura. This is best done by making four drill holes, uniting the upper ones by a cut made by the gigli saw, directing the cut outward and towards the mid-line, so as to produce a bevel. The two legs of the bone flap are completed by the bone cutting forceps. Periosteal elevators are then placed in the upper holes, with their ends beneath the bone flap and used as pries, forcing the flap outward slowly, while the lower end of the flap is firmly held by pressing a heavy instrument over it. This is done slowly and carefully, so as to avoid tearing the dura and the bone flap fractured at its attachment to the skull. Should the dura be densely adherent, it may be separated from the inner table of the bone flap by a delicate separator as the flap is gradually raised. The instrument used by rhinologists, in separating the mucous membrane from the cartilage in the first stage of the operation for submucous resection of the nasal septum, is a splendid instrument for this purpose. Two fine silk sutures are placed near one another about one-fourth inch from the margins of the bone at the upper edge of the defect and the dura carefully nicked with a scalpel. A groove director is then carefully inserted and the dura cut as a large flap.

The dura is gently replaced over the brain, but not sutured, and the bone flap replaced, but not forced into its normal relation with the rest of the skull. The galea and scalp, only, are united by interrupted silk sutures. Dressings are loosely applied, so as to leave the bone flap elevated. This gradually becomes lowered as the edema recedes, finally resting on its bevelled edge.

Insert Figure 59 is a photograph of an osteoplastic decompression showing the bone flap and dura reflected. Insert Figure 60 shows the dura laid over the surface of the brain. Insert Figure 61 shows the bone and scalp flap replaced and ready for suture of the scalp.

One of the simplest and most exasperating problems, which confronts the surgeon in operative head cases, is to properly apply the dressings and keep them there. The writer has solved this problem by using a sterile towel and wrapping it about the head and dressings as one would do up an ordinary package. It is fastened by safety pins and a chin strap improvised by using a strip of muslin, about two inches wide, and fastening it to either side of the towel bandage by safety pins. See Inserts Figures 62, 63 and 64.

Disturbances, or loss of speech, memory, vision, or hearing, or changes in character may occur following head injuries, depending upon the cortical portions involved. (See Chapter II.) Such changes are usually noticed following the operation, as the condition of the patient may border on unconsciousness, or irrationalism, from a day to weeks following

the injury. Changes in speech are best studied when one may secure the intelligent cooperation of the patient.

It will be remembered, as stated in Chapter II, that the centers of speech are homolateral. These centers are in the left hemisphere in right handed individuals and vice versa. Should loss of the ability to speak result from a destructive lesion in the left hemisphere in a right handed individual, the patient may be taught to talk by teaching him to write with his left hand. This is a tedious process, as one must start all over again, beginning with the letters of the alphabet and learning to identify their respective sounds. The words meaning man, woman, child, watch, etc., are first written and the object pointed to and the sound associated with it. It requires enduring patience and ceaseless repetition. An intelligent child makes a good teacher. In this manner, new centers are established in the opposite hemisphere. Such an individual may be indecisive and vacillating in character, but this must be chanced, rather than to shut the individual out from among his fellows by denying him the right to exchange ideas.

Following a temporary recovery from a head injury, the patient may develop an encephalitis. If the patient is syphilitic, it may be a syphilitic encephalitis, when the patient should receive antisyphilitic treatment. A cerebro-spinal fluid and blood Wassermann should be made in these cases. If the Wassermann tests are negative and the

FIG. 59.

The Osteo-plastic Flap Decompression, showing the bone and dural flap reflected.

FIG. 60.

The Osteo-plastic Flap Decompression, showing the dura replaced, but not sutured. Note the defect in lower anterior portion of bone flap as the result of earlier sub-temporal decompression.

FIG. 61.

The Osteo-plastic Flap Decompression-galeo sutured.

FIG. 62.

The Towel Bandage.

FIG. 63.
The Towel Bandage.

FIG. 64.
The Towel Bandage.

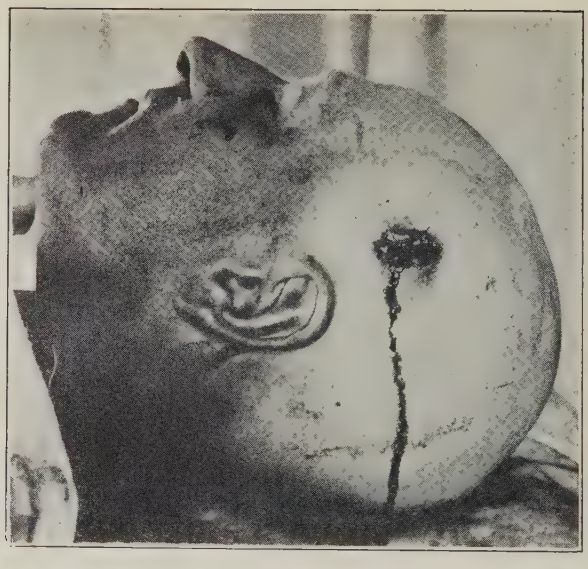


FIG. 65.

Penetrating Wound of left temporal region.

FIG. 66.

Tripod Incision after suture.

FIG. 67.

Tripod Incision after suture.

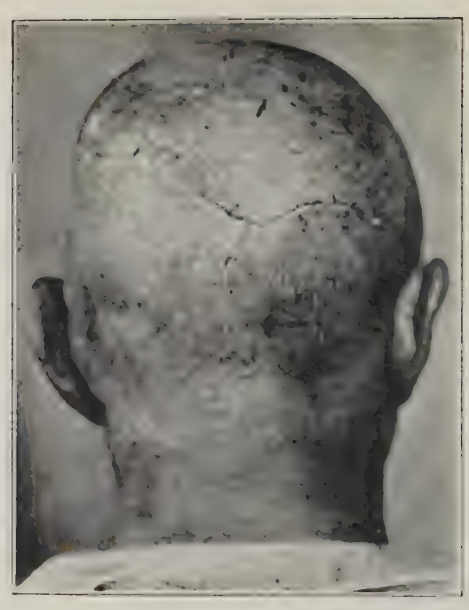


FIG. 68.
Triped Incision-sutures removed.

FIG. 69.
Triped Incision-sutures removed.

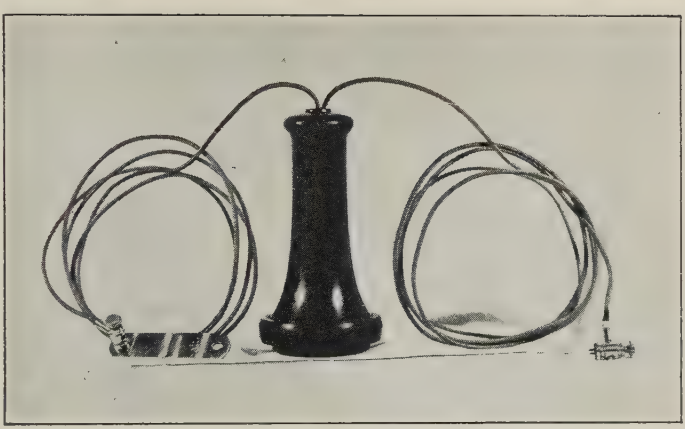


FIG. 75.

The Telephone Probe.

FIG. 76.

Showing drainage favored by gravity.

patient runs only a very slight, or no temperature, one should be suspicious of a traumatic encephalitis. It should be born in mind that lethargic encephalitis may be of the epidemic type and the possibility of this, as a complication, should be considered. Traumatic encephalitis may be acute and accompanied by delirium, hallucinations, violent struggling, etc, It may also develop into a chronic type. The symptoms may resemble the lethargic type in which the patient may sleep for days and weeks. The rectal temperature usually never goes above 100.6; the pulse is often slow and soft; the respirations, 10 to 12 per minute, as in sleep; the blood pressure and intra-spinal pressures are usually below normal, even in old people. If no nephritis exists; the urine is found to be sugar free; the cerebro-spinal fluid and blood Wassermann tests are negative and the cerebro-spinal fluid, otherwise negative and the intra-spinal and blood pressures are found to be normal, or below normal, the patient should be treated as a traumatic encephalitis.

The treatment as carried out by the writer, consists of insuring absolute quiet. The shades should be lowered and the room kept dark. If the patient does not swallow, fluids should be given by rectum as the Murphy drip, or as a hypodermoclysis, if necessary. Easily digestible, or pre-digested foods may be given by the stomach tube and an enema should be given every day. Five to fifteen drops of a saturated solution of sodium iodide are administered three times daily. In cases, where the blood-

pressure is low, thyroid extract, grain one, and pituitary extract (anterior lobe), grains two and one-half are given three times daily in a powder form and mixed with the liquid, or semi-liquid food.

A local encephalitis, or a condition similar to it, is undoubtedly present in all severe head injuries. That this condition should, occasionally, become general is not to be wondered at. The prognosis should be guarded, especially, in old people.

Chapter VII

GUNSHOT INJURIES OF THE HEAD

Because gun-shot injuries of the head, are usually, of a serious nature, involving the skull, dura and brain, only the serious injuries will be discussed. These injuries may be penetrating or perforating. The perforating injuries have wounds of entrance and exit and the causative agent, a bullet, or shell-fragment is not present in the brain. In these cases, all that can be done is to excise the wounds, perform trepanation of the skull at the sites of entrance and exit and cleanse the track in the brain. This is done on either side. The method, used in cleansing the track in the brain, is described in the discussion of penetrating wounds.

Wounds, which perforate one or both of the lateral ventricles, are almost invariably fatal, as the ventricles withstand, even the slightest infection, but poorly. Pieces of bone may be showered into the ventricle from the wound of entrance. In experienced hands, a few may be saved. Dr. Harvey Cushing states the mortality to be 80 per cent. in one of his series of cases of this type, during the World War.

Penetrating wounds of the brain require much patience and care, on the part of the surgeon, for it is not only highly desirable to remove the bullet,

itself, but pieces of indriven bone, hair and filth, that may be carried into the brain by it. All pulped brain must be removed, leaving the track perfectly clean from a mechanical stand-point. All penetrating wounds of the brain should first be given 1500 units of anti-tetanic serum and should be x-rayed to determine the location of the bullet. The case should first be viewed under the fluoroscope, antero-posteriorly and laterally, and marks placed on the head, using a silver-nitrate pencil and designating by a cross. Antero-posterior and lateral views should be taken and the skiagraphs brought to the operating room for the surgeon's reference and help during the operation should it be found difficult to locate the bullet.

In operating upon penetrating wounds of the brain, the tripod, or Isle of Mann incisions, as first described by Cushing, should be used, after excision of the wound has been done. The reader is referred to Chapter IV. Insert Figure 65 is a photograph of a penetrating gun-shot wound in the left temporal region. Inserts Figure 66 and 67 are the photographs of tripod incisions after suture, while Inserts Figures 68 and 69 are photographs of tripod incisions on the third day, when the sutures were removed. Inserts Figures 70 and 71 illustrate the Isle of Mann incision.

After the flaps have been undermined and reflected, trepanation of the skull is done (refer to Chapter V) and the bone about the local fracture removed

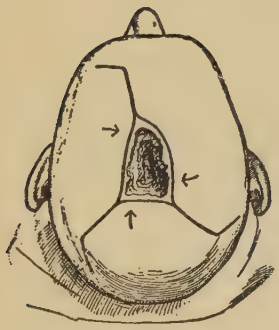


FIG. 70.
Illustrating the use of Isle of Mann Incisions.

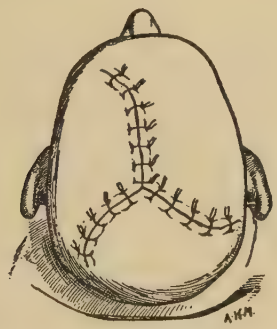


FIG. 71.
Illustrating closure when Isle of Mann incisions are used.

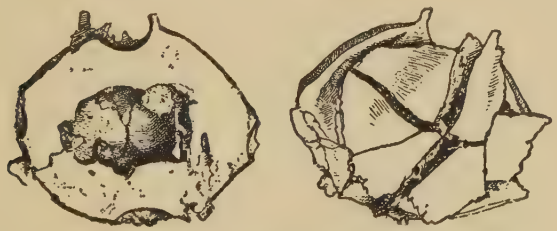


FIG. 72.
Illustrating the appearance of the external and internal surfaces of a piece of skull removed en bloc.

en bloc. Figure 72 is an illustration, showing the external and internal surfaces of a piece of skull removed en bloc.

Pieces of bone, found in the perforation in the dura, are removed and the patient is requested to cough, when pulped brain and debris will extrude. This is gently wiped away and a soft nosed rubber catheter inserted through the perforation in the dura and into the brain to locate foreign bodies. Figure 73 illustrates the use of the catheter in

FIG. 73.
Illustrating the use of the catheter in locating foreign bodies in the brain.

locating foreign bodies in the brain, pulped brain and smaller debris may be removed from the track in the brain by gentle suction, attaching a glass

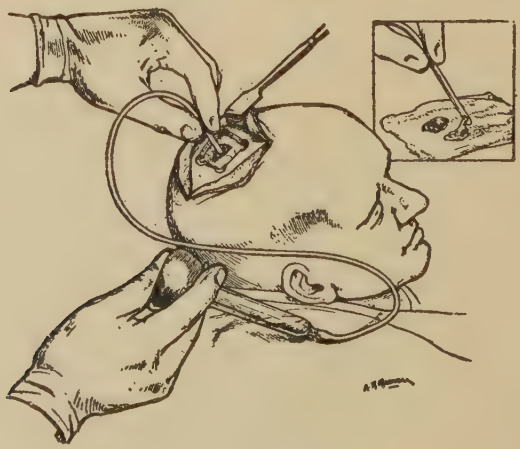


FIG. 74.
Illustrating the use of the catheter, syringe and bulb in applying gentle suction in cleansing the track in the brain.

syringe with bulb for this purpose. Figure 74, with insert, illustrates the use of the rubber catheter, syringe and bulb, in applying suction to cleanse the track in the brain. As the foreign bodies (bullet and larger pieces of bone) are located, they are removed by Cushing's esquillectomy forceps. See Figure 54 in Chapter V.

When the bullet has been removed, the track should be carefully explored by the catheter for pieces of bone, which, if present, should be removed by the esquillectomy forceps. Gentle suction should be applied to remove pulped brain at the bottom of the track. When the track is clean, a small quantity of ethyl alcohol should be injected into the track on the withdrawal of the catheter and the galea and scalp closed by interrupted silk sutures. Interrupted No. 00 chromic gut sutures may be used in the galea, if desired. The sutures in the scalp should be removed on the third day.

In searching for bullets, if steel, or copper jacketed, where more than one bullet are in the brain and several tracks exist, or in turning down an osteo-plastic flap, opposite to the wound of entrance, to search for the bullet, a telephone probe is of great help. A telephone probe consists of an ordinary telephone receiver and its two wires, to one of which is attached a silver probe 9 inches in length and to the other, a piece of metal. The metal piece is placed in the mouth of the patient, taking the precaution to avoid contact with metal fillings. An assistant holds the telephone receiver to the

ear of the operator, while he searches the track, or needles the brain in the area where the bullet seems to lie. If the probe comes in contact with a steel-fragment, or a copper or steel jacket, a "sputtering" is heard, like in the presence of over-charged electricity. Figure 75 is a photograph of the telephone probe.

When the catheter and the telephone probe fail to locate the bullet, its removal may be attempted under the fluoroscope, if one is available. This should never be done, unless all other methods fail, as, very often, much added damage is done to the brain. The finger should not be used to locate foreign bodies in the brain, unless the wound is very large.

A method, employed during the late war, was to use an electro-magnet with a nail attached. The nail was introduced into the track in the brain and, if near the bullet or shell-fragment, it was attracted by the magnet and so removed.

Wounds of entrance, involving the orbit and in which the eye is destroyed, are best treated by enucleating the eye and passing the catheter into the brain through the defect in the orbit, as in cases where trepanation is done. In perforating wounds, where the bullet enters from above and lies near the basilar process of the occipital bone and in front of the spine, it is best to remove the bullet through the wound, following the original track. Wounds below, where the bullet enters the skull through one of the greater wings of the sphenoid, are treated

FIG. 80.
Photograph of patient before operation for skull repair.

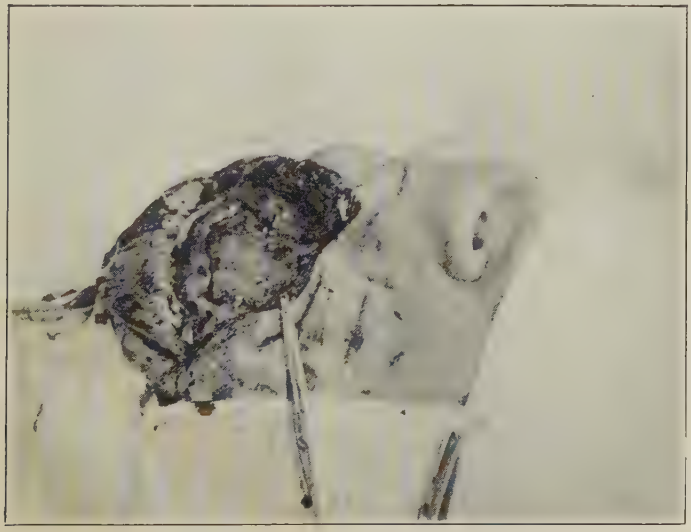


FIG. 81.
Showing defect in skull exposed.

FIG. 82.
Showing costo-chrondral rib selected for graft exposed.

FIG. 83.
Showing the cutting of the graft.

FIG. 84.
Graft ready for application to skull defect

FIG. 85.
Graft in place with cut surfaces external. The two forceps indicate the length of the costo-chondral rib in the lower part of the defect.

FIG. 86.
Showing the appearance of the forehead after suture of the frontalis muscle.

FIG. 87.
Showing the appearance of the forehead after suture of the skin.

by first rendering approach possible. This is done by making an incision over the zygoma and back of the angle of the jaw. The zygoma is resected and the opening in the greater wing of the sphenoid is enlarged by the use of a small curved rongeur. The catheter is introduced and the same technique followed as already described.

In badly infected cases, coming to the surgeon late, a drain should be inserted down to the dura, but not into the brain, at some dependent point that will favor drainage by gravity at the completion of the operation. Insert Figure 76 is a photograph of a case, in which such a drain was used.

Hernia cerebri is one of the most dreaded complications of injuries to the head, involving the brain. This condition is the result of infection, with a failure of union of the scalp. Various factors may contribute toward favoring its development. Incomplete operations, in which the foreign body and pieces of indriven bone have not been removed, favor the formation of brain abscess. If too much tension at the lines of suture exists, or, if the suturing has been carelessly done, union of the scalp fails to take place and the scalp-wound opens widely. If the galea is not sutured and the scalp sutures are allowed to remain from 7 to 10 days, infection from the outside may find entrance along the sutures. The scalp sutures should be tied with slight tension, so as to avoid cutting through the scalp by the sutures. In badly infected, or neglected

cases, the hernia cerebri may exist when brought to the surgeon.

The treatment of hernia cerebri, as practiced by the writer, is as follows: The hernia cerebri is cut away, using a pair of sharp scissors, avoiding any disturbance of its attachment to the dura. Wet dressings of Dakin's solution or ethyl alcohol are applied. The patient is kept in a semi-reclining position and repeated lumbar punctures performed. The semi-reclining position favors reduction by gravity and the repeated lumbar punctures relieve the excessive amount of fluid present, as the recession caused by gravity when a small amount of cerebro-spinal fluid is removed, seems to limit the amount which tends to become stationary. The lessened intra-cranial pressure favors a more free circulation of the cerebro-spinal fluid and its more normal reabsorption. If the hernia recedes and the infection clears up, an attempt to cover with healthy scalp, making a thorough excision of the margins of the scalp-defect, should be made. Great care should be exercised to avoid all tension at the lines of suture, suturing, both galea and scalp, with interrupted silk sutures. The patient should be kept in a semi-reclining position, following the operation, repeating the lumbar punctures, if much bulging is noticed. If it heals rapidly, a costo-chondral graft, using cartilaginous ribs the same thickness as the skull, should be placed in the defect after four weeks. A large pad should be placed over the site of the graft to prevent bulging. This pad should be kept

firmly in place, except, at such times as it becomes necessary to remove the sutures, or inspect the wound, for three months, when the graft has become firmly imbedded and no further bulging, with displacement of the graft, can take place. When the toilet of the track in the brain has been mechanically perfect and the patient operated upon within 12 hours following the injury, abscesses very rarely develop.

Tangential wounds, in which the skull seems, apparently, intact, may have pieces of internal table showered into the brain. These cases, often, develop brain abscess. These abscesses should be approached by drilling through the skull at the site of the injury. The abscess is usually found beneath the skull at this point and the abscess may be opened, directly, without breaking the lateral abscess walls, or disturbing the adhesions of the abscess walls to the dura. In this way, one does not introduce infection into the uncontaminated subdural space and most of the cases recover. When the abscess is approached through the uncontaminated sub-dural space, the mortality is greatly increased.

All foreign bodies in the brain should be removed at the first operation, if at all possible, for, if brain abscess, meningitis, or encephalitis do not develop, any attempt at its removal, later, is always a serious matter. The mortality in these cases is high. Tetanus may develop, following such an operation, as late as two years after the injury.

Chapter VIII

THE COSTO-CHONDRAL GRAFT

It is generally conceded that preference should be given to the autograft over the heterograft in operations for the repair of skull defects. The indications for skull repair are rather obscure in the minds of many, but most of them admit that it is justifiable in large, pulsating defects, or defects with marked deformity. Skull defects may be classified as: large or small; pulsating or non-pulsating; frontal, occipital, parietal and defects of the vault. Skull defects, requiring graft for repair, are usually the result of injuries to the skull and operations made necessary thereby. It is of utmost importance in operations on the skull to avoid larger defects than are required to properly care for conditions that may be found beneath the injury in the skull. For this reason, the writer avoids trepanation in depressed fractures of the lower frontal and occipital regions, where the bone is dense and thick. In injuries of this nature, the margins of the depression are enlarged by rongeurs, unless the injury is over a sinus, when trepanation is always done.

The indications for skull graft are (1) defects, which pulsate and cause headache, vertigo, nausea and weakness at rest, or on exertion; (2) defects,

which cause interference with speech, vision, memory and which cause spasticity, or changes in character; (3) for cosmetic reasons. Let us, for a moment, consider the existing condition in an old cerebral injury with a pulsating defect over a "live" area. For the sake of illustration, we may consider a defect over the motor area. Below the defect we have a scarred brain, with, perhaps, adherent membranes. If no cyst is present, this healed portion of the brain, on stooping, or exertion, is forced into the defect with the following result: a certain amount of edema, more or less is constantly present and any condition, as epilepsy, spasticity, et cetera, is aggravated. This is not so noticable in cases with very small, or very large defects, but in those, where the defect is large enough to permit of a pinching of brain surface. The convexity of the brain, when forced into a defect of 3 or 4 cm. by 6 cm. is very marked, whereas, in a large defect, the convexity is only slight. The more marked the convexity, the tighter is the pinching process and the resulting injury and edema of the part involved, proportionately greater. See Figure 77. When one recalls the importance of the cortical centers, the importance of avoiding the slightest irritation to them will be realized.

It has been the practice of some surgeons to use thin cartilage grafts, but this has fallen into disrepute, because such grafts absorb. The writer uses a graft from one-half to two-thirds the thickness of the chondral rib. Such grafts do not absorb,

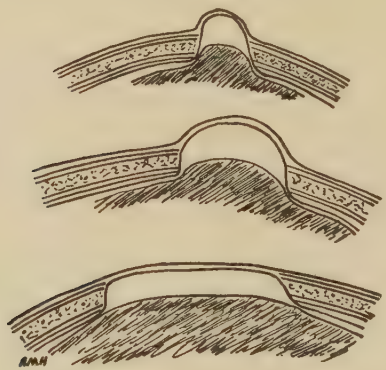


FIG. 77.

Illustrating the "pinching" of cerebral cortex and how the convexity is less marked in large defects.

but become firmly embedded, affording a dense protective layer.

The technique of the operation is, briefly, as follows: the head is painstakingly shaved and prepared by washing with tincture of green-soap and sterile water; sponged with ethyl alcohol and dried by sponging with ether. The site of choice for securing the graft is over the costo-chondral cartilages of the 5th, 6th and 7th ribs, either side. See Figure 78. The chest is prepared by applying a 10 per cent. tincture of iodine. Using a one-half per cent. novocain solution of 60 c. c. to which 1-32 gr. of adrenalin chloride has been added, a block of scalp about the defect is injected; also, a block of skin, including the deeper structures, at the site selected for securing the graft. The old incision over the defect is reopened, if tripod, or a tripod incision made, exposing well beyond the margins

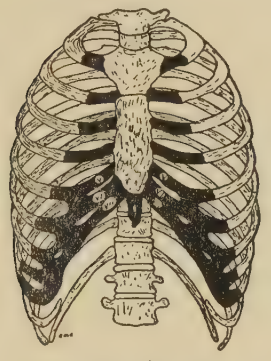


FIG. 78.
Illustrating the sites of choice in selecting material for the costo-chondral graft.

of the defect, carefully separating the galea, or muscle, from the dura. The dura, adherent to the margins of the defect, is freed by the use of the dural separator. A piece of sterile muslin is laid over the opening in the skull and an exact duplicate, the size and shape of the desired graft, is obtained. With the costo-chondral cartilages exposed, this is laid over the cartilages and a one-half to two-thirds thickness of longitudinal sections of the costo-chondral cartilages are cut. Taking care that the head-wound is dry and all clotted blood removed, it is carefully sponged with ethyl alcohol and the graft laid on the dura with the smooth uncut surface inward. The scalp is now sutured in layers, using interrupted No. 00 chromic gut in the galea, or muscle, and interrupted silk sutures in the scalp. In large pulsating defects of the vault, it is better to use interrupted silk sutures in the galea. A pad of sterile gauze is placed directly over the defect

and graft and secured by wide adhesive strips in such a manner as to keep the graft firmly in place and prevent bulging. This pad is changed and carefully readjusted in three, or four days, when the silk sutures are removed; again, one week later and, again, ten days later. At the end of three weeks ,the graft is, usually, firmly embedded. In small defects, or in non-bulging defects, all dressings may be removed at this time. In large defects, the writer keeps the pad in place for six weeks to three months. When the hair begins to grow, the adhesive strips are useless, so a four tail bandage is used, fastening two of the tails beneath the jaw and the other two beneath the occiput and tying the lateral free ends on either side to one another.

In heterografts, where silver, gold, celluloid, or any other substance is used, the "man-hole" has simply been given a cover. The defect of the internal table and its space above (5 to 8 mm., which includes the entire thickness of the skull) still affords an internal hernia, into which the brain may be forced under conditions which increase intra-cranial pressure, as straining at stool, stooping, lifting, et cetera. In this manner, a chronic localized edema may be only slightly benefited, or not at all. The autograft of costo-chondral cartilage, that is one-half to two-thirds the thickness of the normal rib, restores the normal thickness of the bony covering and prevents all possibility of irritation. With the internal table restored, a chronic localized edema will gradually subside. See Figure 79.

FIG. 88.
Showing how the fields of operation are prepared, which permits the operator to transfer the graft from the chest directly to the skull defect without unnecessary handling.

FIG. 89.
Showing the result six weeks after the operation for skull repair.

FIG. 79.

Illustrating the restoration of the internal table when the costo-chondral graft is applied as described by the author.

The following photographs of a case with a frontal defect in which the operation was done for cosmetic reasons, are shown, because they clearly demonstrate the technique of this simple operation. Figure 80 is a photograph of the individual before operation. Figure 81 reveals the defect in the skull exposed. Figure 82 shows the exposure of the 6th and 7th costo-chondral ribs on the right side. Figure 83 demonstrates the simple method used in cutting the graft. Figure 84 reveals the graft ready for transplantation. Figure 85 shows the costo-chondral graft filling the defect. The two forceps indicate the extent of the lower piece of chondral rib. Figure 86 shows the appearance of the forehead, after suture of the frontalis muscle. Figure 87 is a photograph, showing the appearance of the forehead after suture of the skin. Figure 88 shows how the fields of operation are prepared, allowing the operator to transfer the graft directly from the chest wound to the skull defect. Figure 89 is a photograph of the patient six weeks after operation.

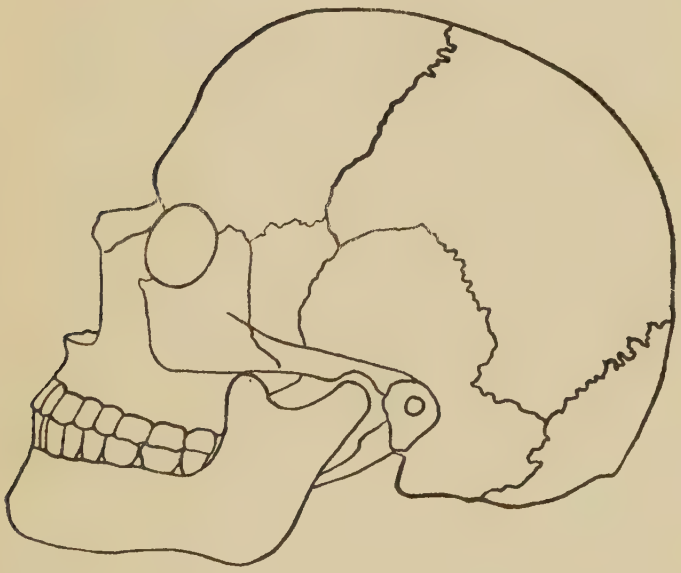
The simplicity of this operation and the universally good results obtainable by it should appeal strongly to the surgeon who wants results.

APPENDIX

A Few Suggestions Relative to the Recording of Head Injuries

In recording head injuries, it should be borne in mind that exact, not necessarily exhaustive records should be kept by the surgeon, himself. Such records should be made with the object in view of giving definite information to the Neurologist, under whose care the patient may ultimately come. An easy and definite method of recording is by the use of diagrams. To facilitate this method of recording, the writer, during the late War, made use of rough pencil sketches of the skull and mesial and lateral aspects of the brain. Two sheets should be used, preferably 5 by 7 inches. One sheet, Figure 90, represents the skull and its sutures, while Figure 91, represents mesial and lateral aspects of the brain and simple front and lateral views of the skull for indicating the location of foreign bodies, as shown by the X-Rays.

Chart of skull and its sutures.

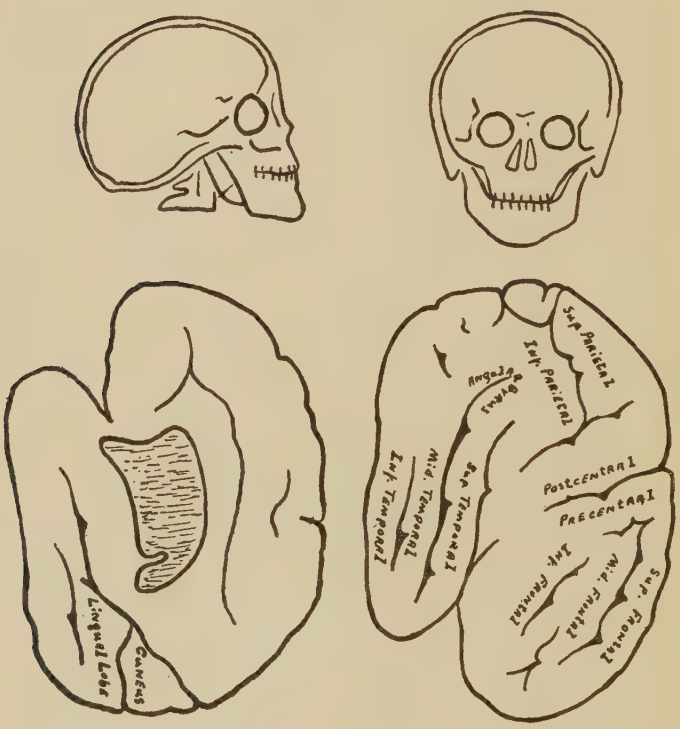


Name

No. *Date*

FIG. 90.

Chart of Brain.



Name

No. *Date*

FIG. 91.

Sheet No. 1 (Fig. 90) may be used to indicate the location of fractures. Sheet No. 2 (Fig. 91) will be used to indicate the site of the lesion, or lesions, in the brain, right or left side being specified on the chart. Both sheets should be made out for cases in which the brain is involved. The operation, or operations, may be recorded on the back of the sheets.

A brief reconsideration of the cortical centers will illustrate the simplicity and reliability of such records. (See Figures 15 and 16 in Chapter II.) A circle, or any other suitable mark, drawn about the area involved, which may be rather definitely determined at the time of operation and immediately following the operation, will afford a reliable and valuable record.